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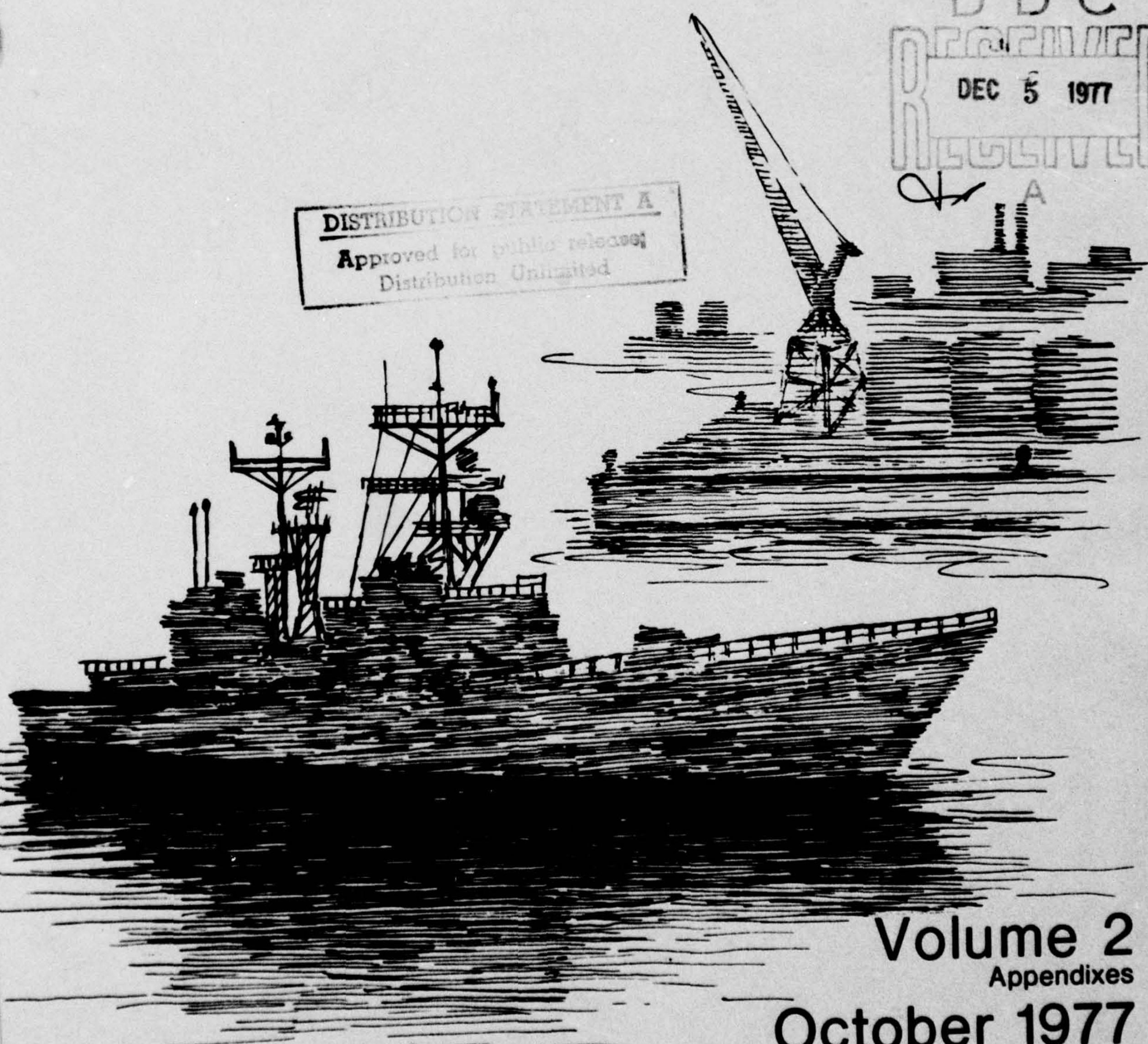

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October 1977

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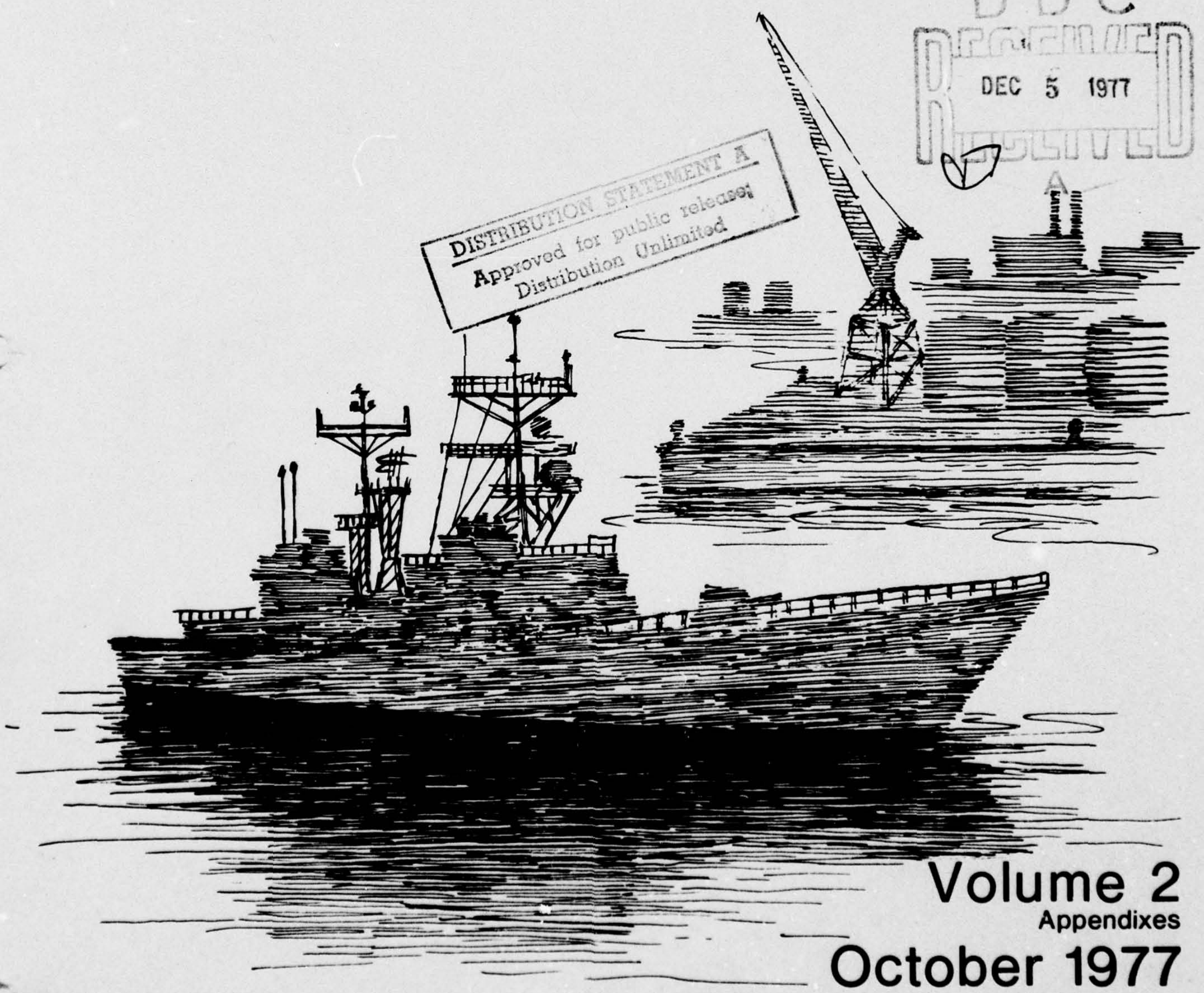

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U.S. NAVY ENERGY AND NATURAL RESOURCES
RESEARCH AND DEVELOPMENT OFFICE

TT-A-872-77-335

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October 1977

U.S. NAVY
ENERGY RESEARCH AND DEVELOPMENT
PROGRAM PLAN
(FY 1978 THROUGH FY 1983)

PREPARED UNDER THE DIRECTION OF THE DIRECTOR, NAVY ENERGY AND NATURAL RESOURCES RESEARCH AND DEVELOPMENT OFFICE

TETRA TECH, INC.
1911 North Fort Myer Drive
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This document presents a program plan developed to establish a course of action whereby the Director, Navy Energy R&D Office, may effectively carry out the responsibilities of his assigned charter, and to provide the Navy with a structured approach to energy R&D that responds to Navy energy requirements and at the same time complements and becomes an integral part of the national and Department of Defense energy R&D programs. Also discussed in this document is the methodology used in developing the plan, including the selection of goals, strategies and objectives for the Navy Energy R&D program.

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U.S. NAVY ENERGY AND NATURAL RESOURCES
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ABBREVIATIONS

AEUTB	Advanced Energy Utilization Test Bed
ASD	Assistant Secretary of Defense
ASN	Assistant Secretary of the Navy
BOE	Barrels of Oil Equivalent
BOM	Bureau of Mines
BUMED	Bureau of Medicine
CEL	Civil Engineering Laboratory
CNM	Chief of Naval Material
CNO	Chief of Naval Operations
COED	Char-Oil Energy Development
CONUS	Continental United States
DCNO	Deputy Chief of Naval Operations
DC/S RD&S	Deputy Chief of Staff for Research, Development and Studies
DDR&E	Director, Defense Research and Engineering
DEIS	Defense Energy Information System
DETG	Defense Energy Task Group
DFSC	Defense Fuel Supply Center
DLA	Defense Logistics Agency
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DSFSG	Defense Synthetic Fuels Steering Group
DTNSRDC	David Taylor Naval Ship Research and Development Center
ECIP	Energy Conservation Investment Program
EMCS	Energy Monitoring and Control System
EPA	Environmental Protection Agency
EPCA	Energy Policy and Conservation Act
EPRI	Electric Power Research Institute
ERDA	Energy Research and Development Administration
FEA	Federal Energy Administration
FPC	Federal Power Commission
FR/IED	Foundation Research and Independent Exploration Development
FYDP	Five-Year Development Plan
HQMC	Headquarters, Marine Corps

HVAC	Heating, Ventilating, and Air Conditioning
ISA	International Security Affairs
JCS	Joint Chiefs of Staff
JSCERDCG	Joint Services Civil Engineering R&D Coordination Group
LNG	Liquid Natural Gas
MARAD	Maritime Administration
MCDEC	Marine Corps Development and Education Command
MOU	Memorandum of Understanding
MRA&L	Manpower, Reserve Affairs, and Logistics
NAD	Naval Ammunition Depot
NADC	Naval Air Development Center
NAPTC	Naval Air Propulsion Test Center
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Command
NAVMAT	Naval Material Command
NAVSEA	Naval Sea Systems Command
NAVSEC	Naval Ship Engineering Center
NBS	National Bureau of Standards
NRL	Naval Research Laboratory
NSGA	Naval Security Group Activity
NSRDC	Naval Ship Research and Development Center
NWC	Naval Weapons Center
OCS	Outer Continental Shelf
O&M	Operations and Maintenance
OMB	Office of Management and Budget
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
PA	Public Affairs
P&E	Planning and Evaluation
POL	Petroleum-Oil-Lubricants
POM	Program Objectives Memorandum
PWC	Public Works Center
PWRMR	Prepositioned War Reserve Materiel Requirements
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RDF	Refuse-Derived Fuel
RDT&E	Research, Development, Test, and Evaluation
RE&S	Research, Engineering and Systems

RFP	Request for Proposals
STEM	Shipboard Total Energy Model
SYSCOM	Systems Command
USGS	U.S. Geological Survey

APPENDIX A

PATTERNS OF ENERGY USAGE IN THE U.S. NAVY

1.0 INTRODUCTION

Inherent in the planning and evaluation of Navy energy policies and objectives is the need for an accurate, Navy-wide system to collect, verify, and display energy usage data. The Navy Energy Usage Profile and Analysis System was designed for this purpose. Development of the initial (FY 1973-74) data base for the system required some extrapolation, which is discussed in this appendix.

2.0 METHODOLOGY OF DEVELOPMENT

The overall approach to identifying the patterns of energy usage in the U.S. Navy has been to gather energy usage and activity level data for Navy ships, aircraft, and shore facilities; sort these data by appropriate consumer function, type, and energy form; and sum the data through appropriate subtotals to obtain a final overall Navy total. Because of input constraints, some data were estimated to provide a more complete Navy-wide presentation, but these estimates represent less than 2 percent of the total. Figure A-1 is an example of how the energy profile system can be used to analyze each consumer platform.

Ship energy usage data gaps were encountered where individual ships occasionally failed to submit a monthly report. Such gaps were bridged, where appropriate, by deriving the average monthly fuel consumption and steaming hours rate for the months reported and applying this average over 12 months. The number of reports involved in this process was less than 2 percent of the reports filed.

Fuel consumption by Military Sealift Command (MSC) operated ships was obtained from MSC headquarters for FY 1973-74 and from the DEIS-I (Defense Energy Information System) reports for FY 1975-76. Although total fuel usage by dry cargo ships in FY 1973 was specified by MSC headquarters, distribution by fuel type was not available. This was estimated from FY 1974 data to be 61 percent, Navy special fuel oil (NSFO); 20 percent, No. 6; 17 percent, diesel; and 2 percent, Navy distillate (ND).

Fuel consumption by ships chartered by MSC was obtained from FY 1974-75 fuel terminal report files of the Defense Fuel Supply Center (DFSC). These data were a compilation of the amounts of fuel issued to commercial ships and billed to MSC. The compilation was limited to the fuel terminals at Subic Bay, Yokoska, Guam, Pearl Harbor, Rodman, and Rota, on the advice of MSC headquarters. Since detailed data were not available for FY 1973, fuel consumption for that period was estimated, based on FY 1974 reports and MSC guidance, to be 1.5 million barrels.

Aircraft energy usage covers the total usage by all Navy and Marine Corps aircraft. Energy usage was calculated from total flying hours and aircraft type fuel consumption

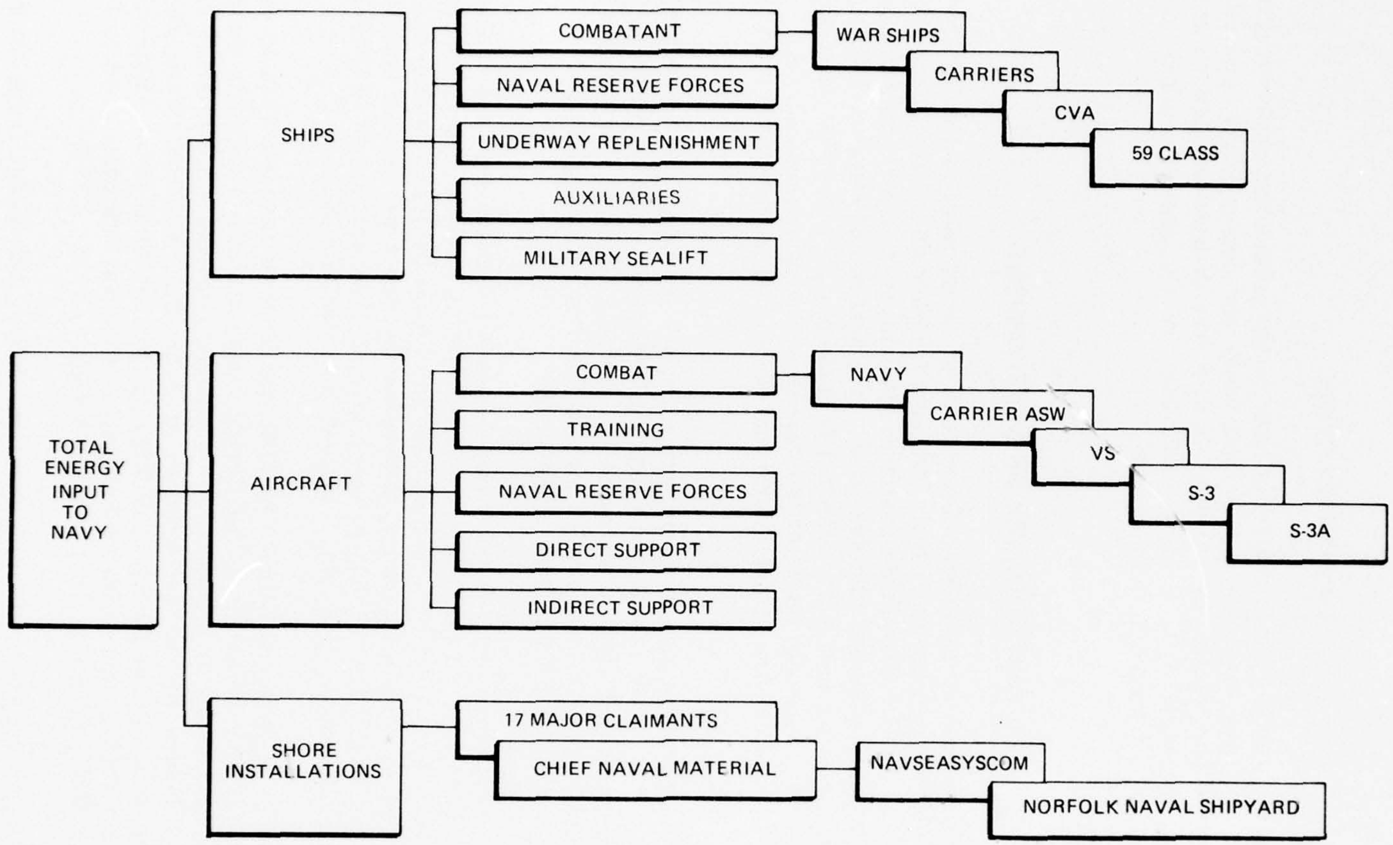


Figure A-1. U.S. NAVY ENERGY PROFILE FORMAT

rates. Flying hours were sorted by function and aircraft type and the appropriate hourly fuel consumption rate was applied. The consumption so calculated was summed through aircraft types and functions to an overall aircraft total.

Shore facilities utility energy usage was compiled by the Naval Facilities Engineering Command (NAVFAC) headquarters. FY 1973-74 usage was compiled from the Reduced Energy Consumption Report, and FY 1975-76 usage was compiled from DEIS-II reports. The data were sorted by major claimant and energy type, and were summed to determine overall facilities utility energy usage. The results presented for FY 1973, FY 1975, and FY 1976 are worldwide totals. FY 1974 data, however, were collected only for the 50 states. Overseas utility energy usage for FY 1974 was obtained from an earlier study of facility energy usage done by David W. Taylor Naval Ship Research and Development Center (DTNSRDC). These data were added by energy form to the NAVFAC results to give worldwide totals. Sufficient detail was not available to divide the overseas usage by major claimant.

Energy used by shore installation ground support equipment was not accumulated by NAVFAC. Ground support data available from an earlier DTNSRDC study, however, were not considered reliable. FY 1973 baseline data were taken from an analysis of the DEIS-I reports. The FY 1974 usage was estimated by scaling up the DTNSRDC FY 1974 data by the ratio of OP-413's FY 1973 data to DTNSRDC's FY 1973 data. Ground support energy usage in FY 1975-76 was taken from the DEIS-I reports.

Navy energy costs were calculated in several ways. Ship and aircraft fuel costs were derived by multiplying computed fuel usage by the average costs of each fuel for the fiscal year. Although, in reality, usage rates vary, the usage rate was assumed to be constant throughout the year for ease of calculation. It was believed there would be no significant error introduced by this method. Shore energy costs for FY 1975 and FY 1976 were provided by NAVFAC. Shore costs for FY 1973 and FY 1974 were calculated from average costs per energy type and the amount of each energy type used as supplied by NAVFAC.

3.0 ENERGY CONVERSION FACTORS AND AVERAGE ENERGY COSTS

Table A-1 shows the conversion factors used in the energy profile system. Because the heating or thermal value of a fuel is related to its API gravity, an average value for each type was used. Table A-2 shows the average cost to the Navy of each energy form for FY 1973-76, and estimated energy costs for FY 1977.

4.0 ENERGY UTILIZATION COMPARISON, FY 1973-FY 1976

As shown in Figure A-2, the Navy reduced total energy consumption 20.1 percent in FY 1974, 21.7 percent in FY 1975, and 25.8 percent in FY 1976, as compared with the

Table A-1. ENERGY CONVERSION FACTORS

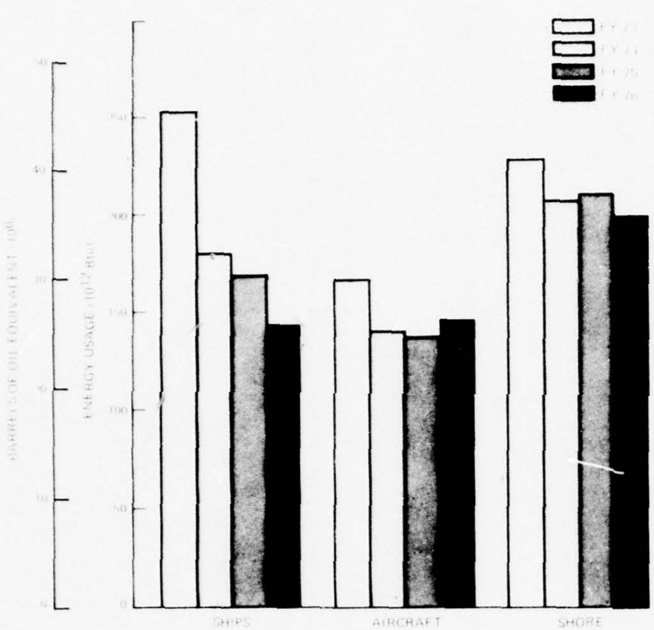
Energy Form	Quantity Unit	Btu[a] per Quantity Unit
Automotive gasoline	bbl[b]	5.25×10^6
Aviation gasoline	bbl	5.25×10^6
Jet fuel, JP-4	bbl	5.34×10^6
Jet fuel, JP-5	bbl	5.67×10^6
Kerosene	bbl	5.67×10^6
Diesel fuel	bbl	5.83×10^6
Distillate fuel oil, No. 2	bbl	5.83×10^6
Navy distillate fuel oil (ND)	bbl	5.95×10^6
Navy special fuel oil (NSFO)	bbl	6.22×10^6
Residual fuel oil, Bunker C	bbl	6.29×10^6
Propane	gal	95,500
Natural gas	SCF[c]	1,031
Coal, bituminous	short ton	24.58×10^6
Steam	lb	1,000
Electricity[d]	kwh	11,600
Barrel of oil equivalent (BOE)[e]	bbl	5.8×10^6

[a]British thermal unit (Btu).
[b]1 barrel (bbl) = 42 U.S. gallons.
[c]Standard cubic foot (SCF).
[d]FEA value—includes energy expended in the production and transmission of 1 kilowatt hour.
[e]1 million BOE = 10^6 BOE.

Table A-2. AVERAGE NAVY ENERGY COSTS

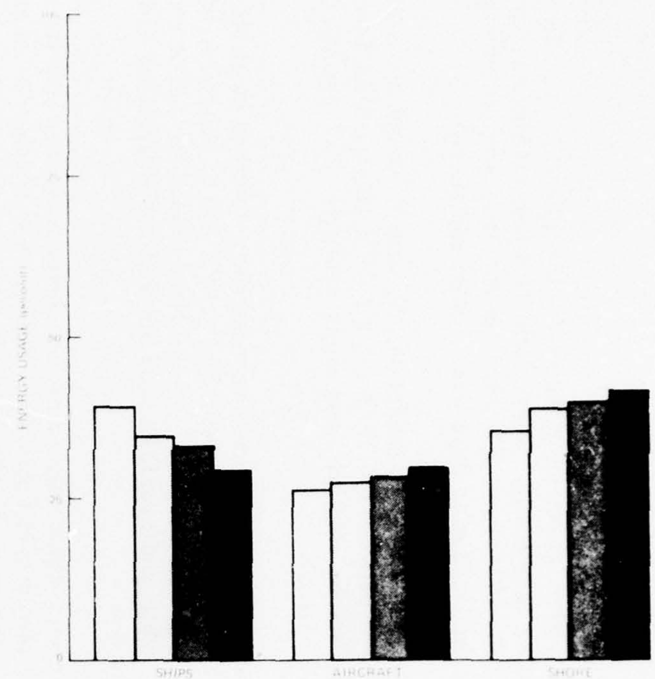
Energy Type	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977[a]
Petroleum fuels (dollars per barrel)					
AVGAS	7.350	12.190	17.387	19.257	19.194
MOGAS	6.160	9.520	15.358	17.199	13.272
JP-4	5.103	9.307	15.400	16.611	18.186
JP-5	5.173	9.409	14.700	16.023	16.170
DFM	4.900	9.037	14.350	15.309	16.170
ND	4.252	9.116	14.659	15.309	16.170
NSFO	3.078	7.672	13.759	14.164	13.146
Shore heating oil	4.470	8.700	12.880	13.340	14.442
Average petroleum[b]	4.458	9.054	14.394	15.959	–
Electricity (cents per kilowatt hour)	1.253	1.844	2.436	2.568	2.847
Natural gas (dollars per million Btu)	0.610	0.720	0.930	1.230	1.870
Propane (dollars per million Btu)	–	–	3.280	4.060	4.260
Coal (dollars per ton)	21.320	26.460	38.960	35.040	31.100
Purchase heat (estimated dollars per million Btu)	1.177	2.148	2.880	3.010	4.620

[a]Estimated.
[b]Average computed on basis of BOEs used of each fuel type.



ACTIVITY	ENERGY USAGE (10^{12} Btu)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
SHIPS	254.5	179.8	169.0	140.9	29.4	33.6	44.6
AIRCRAFT	167.4	139.0	158.8	143.2	17.0	17.1	14.5
SHORE*	227.6	200.1	200.[illegible]	198.8	12.1	11.7	12.7
TOTAL	649.5	518.9	508.7	482.9	20.1	21.7	25.7

*INCLUDES UTILITIES AND GROUND SUPPORT



ACTIVITY				
	FY 73	FY 74	FY 75	FY 76
SHIPS	39.2	34.7	33.2	29.2
AIRCRAFT	25.8	26.1	27.3	29.7
SHORE	35.0	38.6	39.5	41.2

Figure A-2. ENERGY USAGE BY ACTIVITY

baseline year, FY 1973. The greatest reduction was achieved by ships, which used 44.6 percent less energy in FY 1976 than in FY 1973. This reduction in energy usage was achieved in part by a reduction of total steaming hours. Naval aviation units achieved a 14.5 percent reduction in FY 1976, as compared with FY 1973. Flight hours in the same period, however, were reduced significantly. Naval shore facilities reduced their energy usage by 12.9 percent in FY 1976 from FY 1973 levels. There was no attempt to measure activity levels for shore facilities as there was for ships and aircraft.

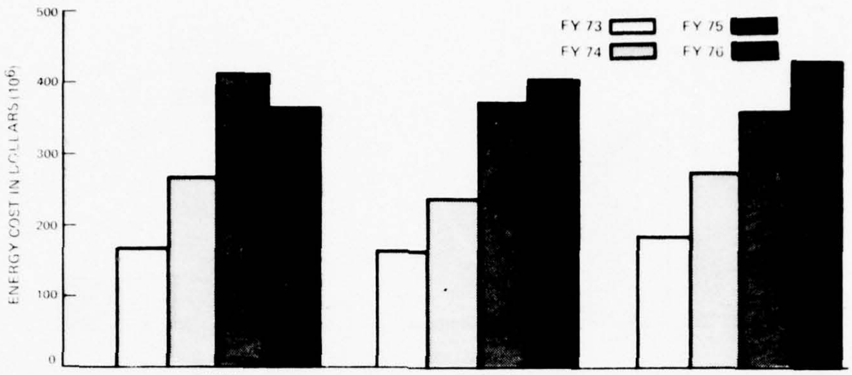
In spite of the reductions in energy consumption, the cost of energy increased by 141.1 percent to $1.206 billion between FY 1973 and FY 1976 (Figure A-3). This cost is nearly evenly distributed among ship, air, and shore activities: 30.2 percent, 34.2 percent, and 35.6 percent, respectively.

Petroleum is the primary energy form used within the Navy, followed by electricity, natural gas, and coal. In FY 1976, the Navy used 350.1×10^{12} Btu of petroleum, which was 73. percent of the total energy consumed by the Navy (Figure A-4). The various forms of petroleum energy usage and quantities used are shown in Figure A-5 and the corresponding costs in Figure A-6.

Detailed data on ship energy usage, ship petroleum energy usage, and ship steaming hours through FY 1976 are provided in Figures A-7 through A-9. Warships account for 59.0 percent of the total energy used in FY 1976. Diesel fuel marine (DFM) was the primary petroleum energy used in FY 1976, totaling 11.7 million barrels or 49.0 percent of the total. This is a significant change in the composition of petroleum usage from FY 1973 when DFM accounted for only 5.2 percent of the total and reflects the trend away from NSFO in an effort to reduce the number of fuel types. The percentage of ship underway time decreased 32.6 percent from FY 1973 and FY 1976.

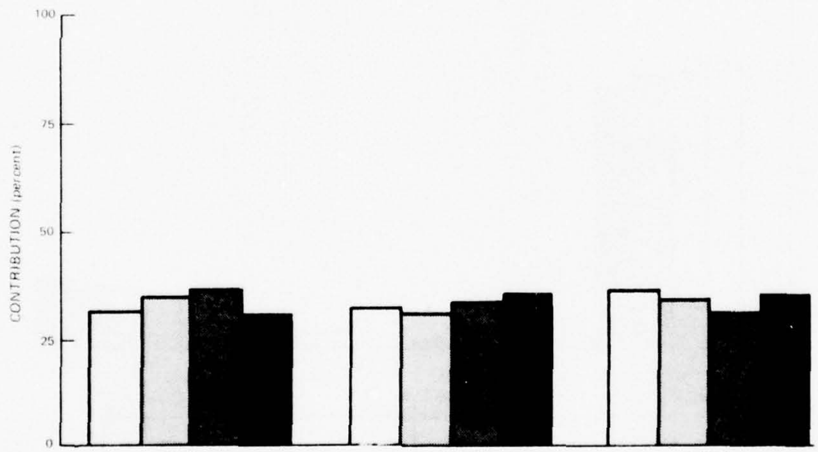
Figures A-10 through A-12 provide detailed aircraft energy usage data similar to the ship data. The amount of petroleum used by aircraft decreased by 14.5 percent between FY 1973-76 (Figure A-11), which is close to the percentage change in flight hours between FY 1973-76 (Figure A-12).

Figure A-13 shows shore energy use by energy form. As activity for ships and aircraft decreased, the shore facilities had to assume an extra burden of support. The lack of some method of quantitatively measuring shore activity makes it impossible to determine how much shore conservation efforts were offset by that increased activity. All that can be determined is a net savings.



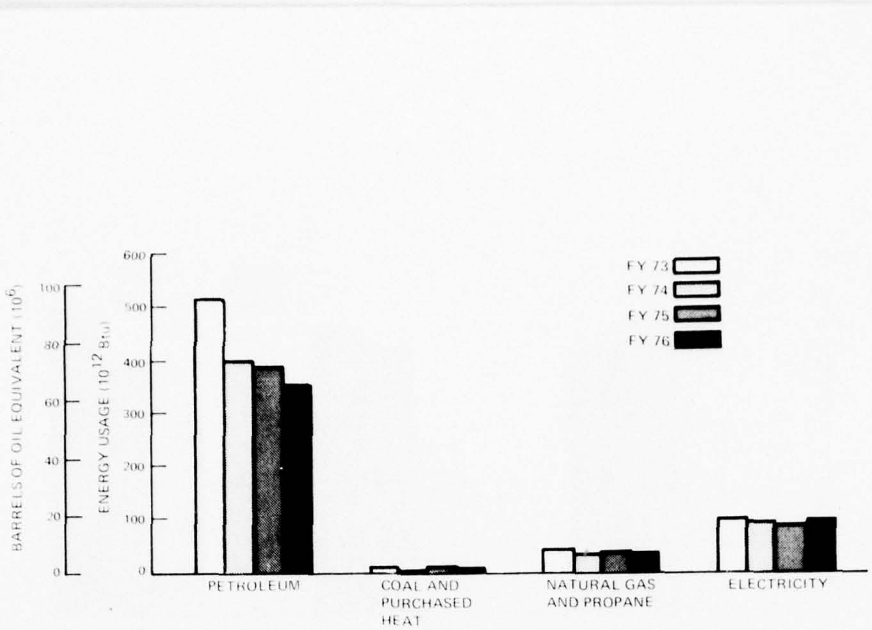
ACTIVITY	ENERGY COST IN DOLLARS (10^6)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
SHIPS	158.060	263.013	414.195	364.482	66.4	162.0	130.6
AIRCRAFT	158.552	238.336	370.433	412.413	50.3	133.6	160.1
SHORE[a]	183.690	269.698	362.836	429.247	46.8	97.0	133.7
TOTAL	500.302	771.047	1147.464	1206.142	54.1	129.2	141.1

[a]INCLUDES UTILITIES AND GROUND SUPPORT

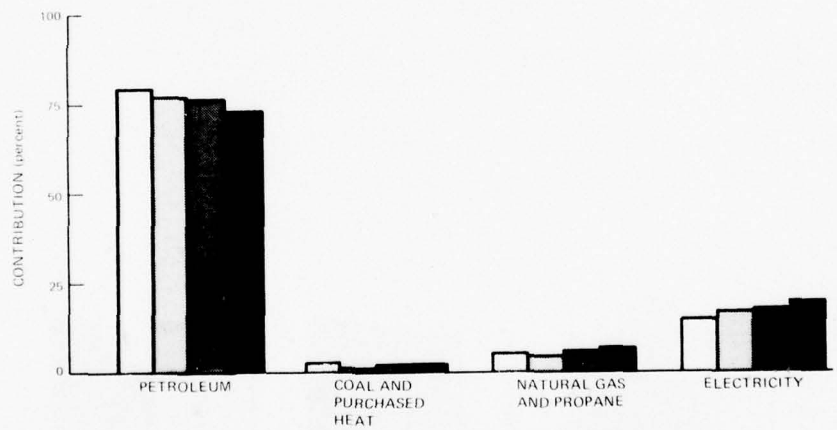


ACTIVITY	CONTRIBUTION (percent)			
	FY 73	FY 74	FY 75	FY 76
SHIPS	31.6	34.1	36.1	30.2
AIRCRAFT	31.7	30.9	32.3	34.2
SHORE	36.7	35.0	31.6	35.6

Figure A-3. ENERGY COST BY ACTIVITY

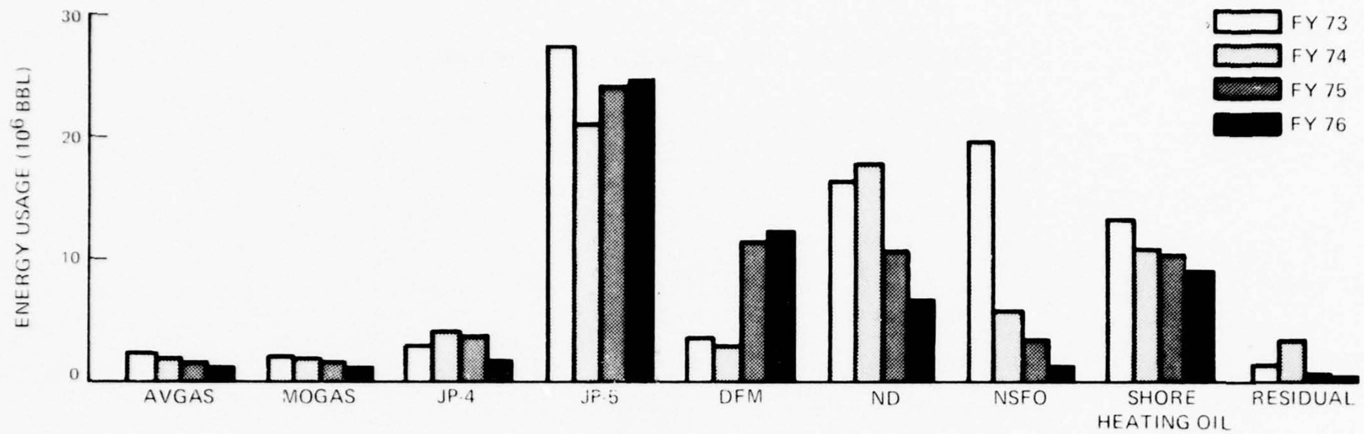


ENERGY FORM	ENERGY USAGE (10^{12} Btu)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
PETROLEUM	513.1	398.4	384.6	350.1	22.4	25.0	−31.8
COAL AND PURCHASED HEAT	5.8	3.4	4.1	3.7	−41.4	−29.3	−36.2
NATURAL GAS AND PROPANE	35.0	26.5	30.3	29.1	−24.3	−13.4	−16.9
ELECTRICITY	95.8	90.6	89.6	94.8	5.4	− 6.5	− 1.0
TOTAL	649.7	518.9	508.6	477.7	−20.1	−21.7	−26.5



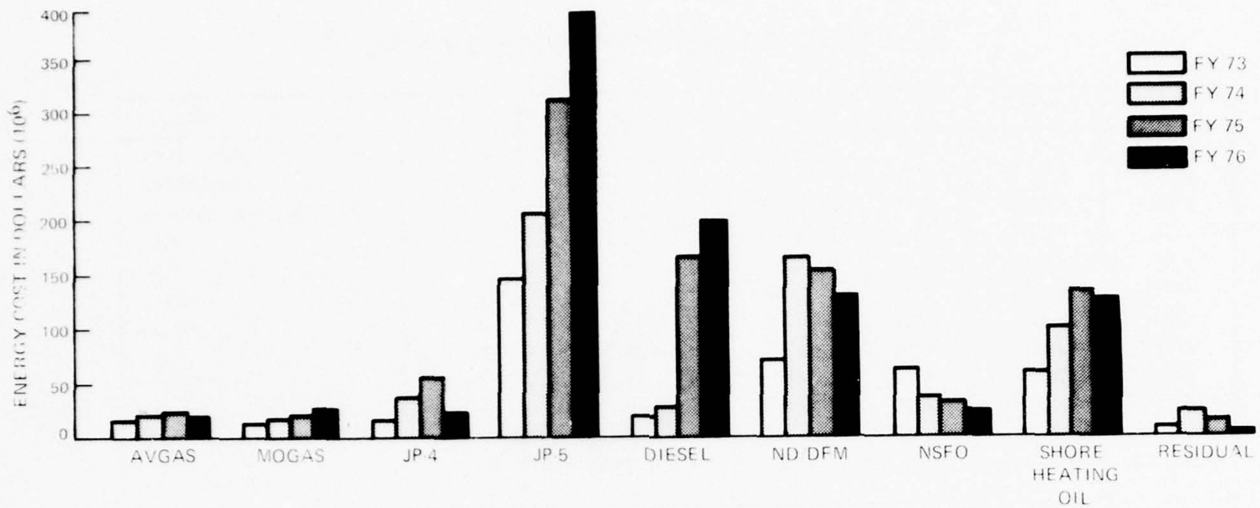
ENERGY FORM	CONTRIBUTION (percent)			
	FY 73	FY 74	FY 75	FY 76
PETROLEUM	79.0	76.8	75.6	73.3
COAL AND PURCHASED HEAT	0.9	0.7	0.8	0.8
NATURAL GAS AND PROPANE	5.4	5.1	6.0	6.1
ELECTRICITY	14.7	17.5	17.6	19.8

Figure A-4. ENERGY USAGE BY ENERGY FORM



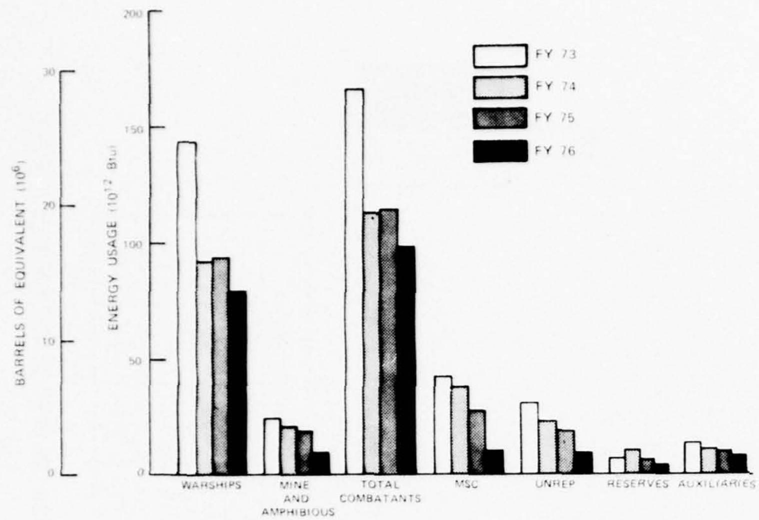
FUEL	PETROLEUM USAGE (10^6 BBL)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
AVGAS	2.1	1.6	1.3	1.1	−23.8	−38.1	−47.6
MOGAS	1.7	1.5	1.3	1.2	−11.8	−23.5	−29.4
JP-4	2.5	3.8	3.4	1.6	52.0	36.0	−36.0
JP-5	27.8	21.6	23.8	24.1	−22.3	−14.4	−13.3
DFM	3.1	2.6	11.4	12.4	−16.1	267.7	300.0
ND	16.2	17.8	10.3	8.9	9.9	−36.4	−45.1
NSFO	19.3	5.5	2.8	1.4	−71.5	−85.5	−92.7
SHORE HEATING OIL	12.9	11.4	10.3	9.6	−11.6	−20.2	−25.6
RESIDUAL	1.7	2.7	0.8	0.5	58.8	−52.9	−70.6
UNDEFINED	—	—	1.1	0.01	—	—	
TOTAL	87.3	68.5	66.5	60.8	−21.5	−23.8	−30.3

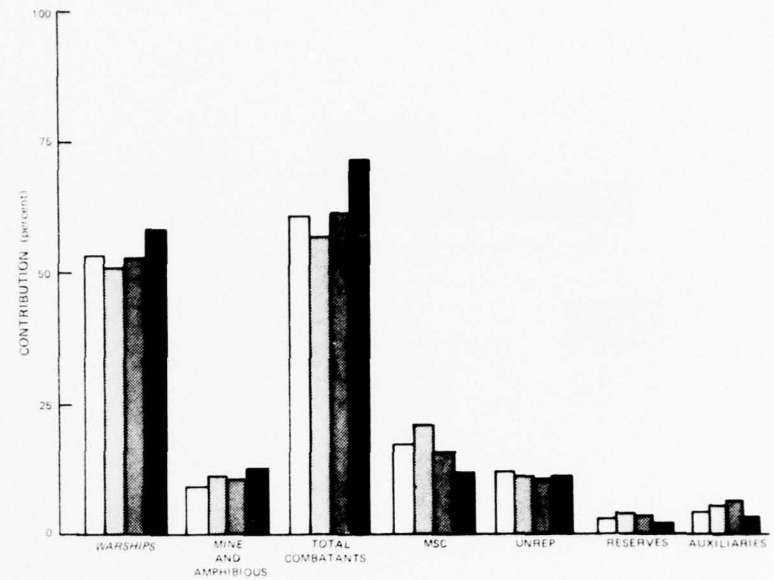
Figure A-5. PETROLEUM USAGE BY FUEL TYPE



FUEL	PETROLEUM COST IN DOLLARS (10^6)			
	FY 73	FY 74	FY 75	FY 76
AVGAS	15.435	19.504	22.603	21.183
MOGAS	10.472	14.280	19.965	20.639
JP 4	12.758	35.365	52.360	26.578
JP 5	143.809	203.225	349.860	386.154
DIESEL	15.190	23.496	163.590	189.832
ND	68.882	162.268	150.991	136.250
NSFO	59.412	42.198	38.524	19.830
SHORE HEATING OIL	57.663	99.180	132.664	128.064
RESIDUAL	5.539	20.715	11.007	7.082
UNDEFINED			15.833	0.160
TOTAL	389.160	620.231	957.397	935.772

Figure A-6. PETROLEUM COST BY FUEL TYPE



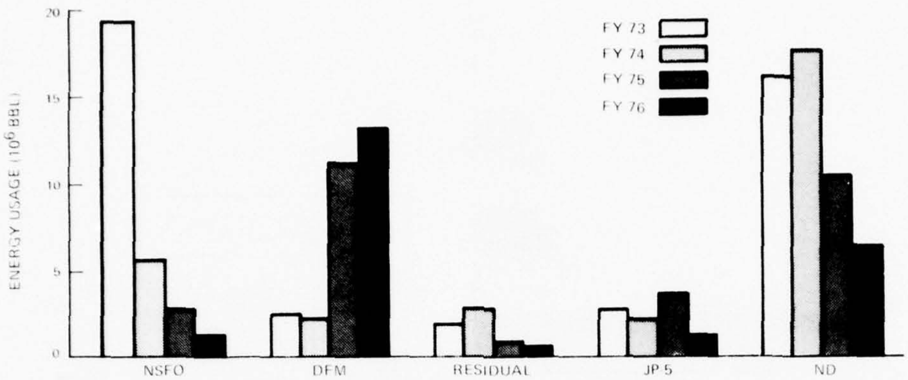


SHIP CLASS	ENERGY USAGE (10^{12} Btu)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
WARSHIPS	143.1	90.4	93.6	82.9	-36.8	-34.6	-42.1
MINE AND AMPHIBIOUS	22.4	19.9	18.2	15.8	-11.1	-18.7	-29.5
TOTAL COMBATANTS	165.4	110.3	111.7	98.6	-33.3	-32.5	-40.4
MSC[a]	42.4	34.8	25.6	15.0	-17.9	-39.6	-64.6
UNREP	29.3	19.4	17.8	14.3	-33.7	-39.2	-51.1
RESERVES	5.1	5.6	4.6	4.4	-9.9	-9.8	-14.7
AUXILIARIES	12.3	9.6	9.3	8.4	-22.6	-24.4	-31.9
TOTAL	254.4	179.7	168.9	140.9	-29.4	-33.6	-44.6

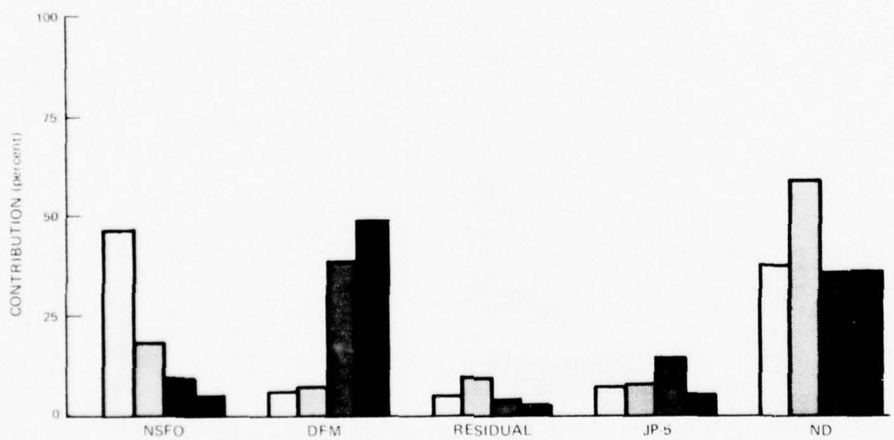
[a]INCLUDES ONLY MSC PURCHASES FROM DFSC STOCKS

SHIP CLASS	CONTRIBUTION (percent)			
	FY 73	FY 74	FY 75	FY 76
WARSHIPS	56.2	50.3	55.3	59.0
MINE AND AMPHIBIOUS	8.8	11.1	10.8	11.3
TOTAL COMBATANTS	65.0	61.4	66.1	70.3
MSC	16.7	19.4	15.1	10.3
UNREP	11.5	10.8	10.5	10.2
RESERVES	2.0	3.1	2.7	3.1
AUXILIARIES	4.9	5.3	5.5	6.0

Figure A-7. TOTAL ENERGY USAGE BY SHIP CLASS (EXCEPT NUCLEAR)

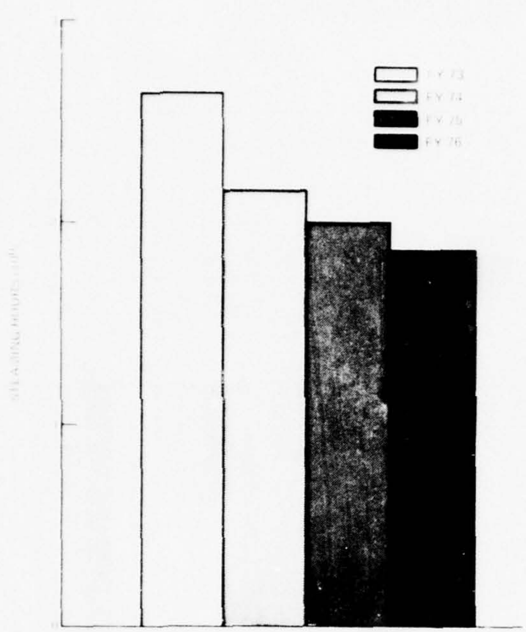


FUEL	PETROLEUM USAGE (10^6 BBL)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
NSFO	19.3	5.5	2.8	1.4	−71.5	−85.5	−92.7
DFM	2.2	2.0	11.1	11.7	−9.1	404.5	431.8
RESIDUAL	1.7	2.7	0.8	0.5	58.8	−52.9	−70.6
JP-5	2.6	2.1	3.7	1.4	−19.2	42.3	−46.2
ND	16.2	17.8	10.3	8.9	9.9	−36.4	−45.1
TOTAL	42.0	30.1	28.7	23.9	−28.3	−31.7	−43.1

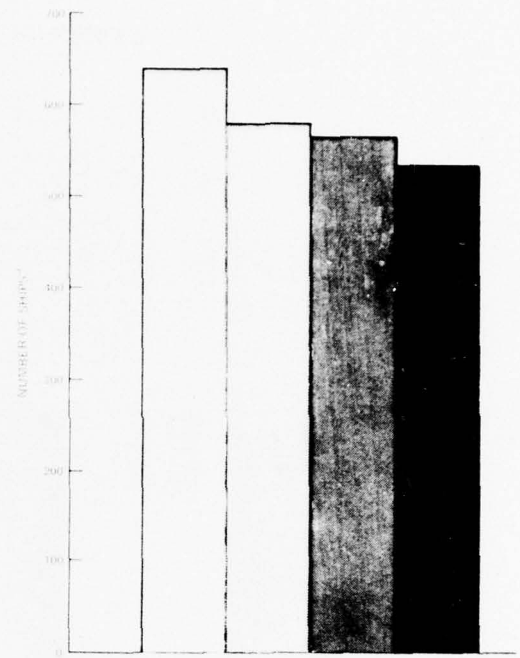


FUEL	CONTRIBUTION (percent)			
	FY 73	FY 74	FY 75	FY 76
NSFO	46.0	18.3	9.8	5.9
DFM	5.2	6.6	38.7	49.0
RESIDUAL	4.0	9.0	2.8	2.1
JP-5	6.2	7.0	12.9	5.9
ND	38.6	59.1	35.9	37.2

Figure A-8. PETROLEUM USAGE FOR SHIPS BY FUEL TYPE

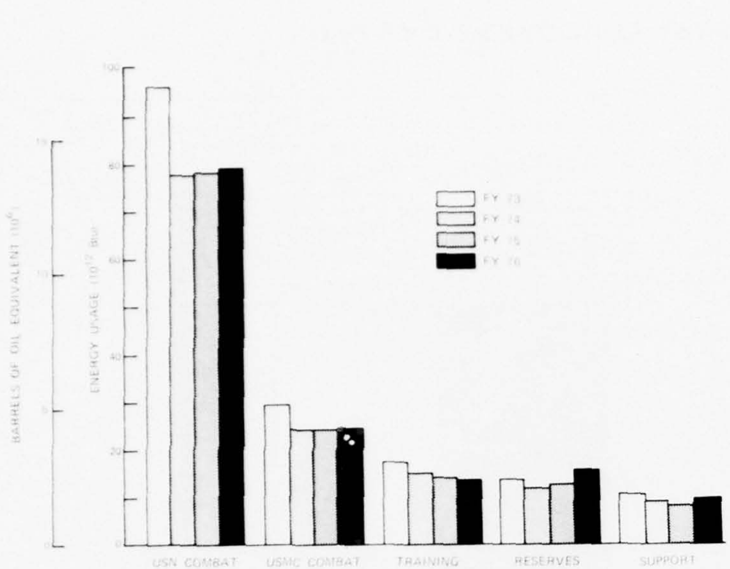


	STEAMING HOURS (10^9)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
UNDERWAY	1.618	1.223	1.147	1.091	24.4	29.1	32.6
NOT UNDERWAY	1.007	0.920	0.847	0.776	8.6	15.9	22.9
TOTAL	2.625	2.143	1.994	1.867	18.4	24.1	28.9

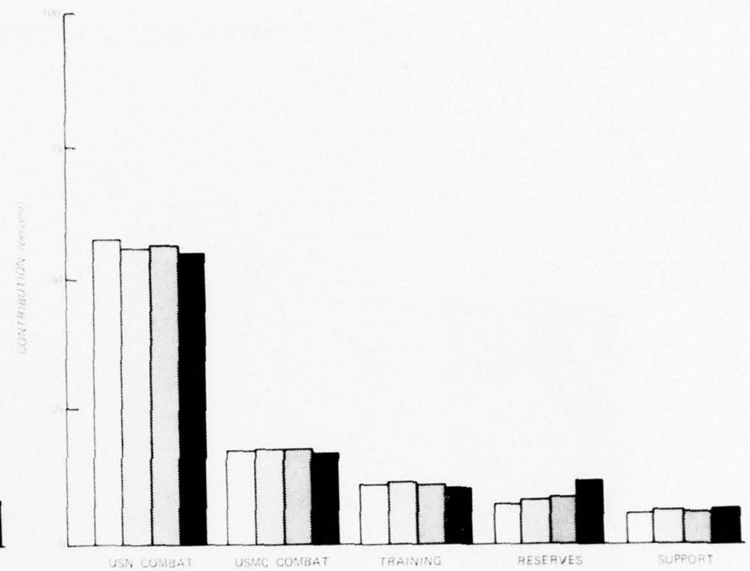


	NUMBER OF SHIPS[a]				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
ACTIVE	584	512	496	476	12.3	15.1	20.5
RESERVE	59	67	63	60	13.6	6.8	1.7
TOTAL	643	579	559	536	10.0	13.1	16.6

Figure A-9. SHIP ACTIVITY AS MEASURED BY STEAMING HOURS

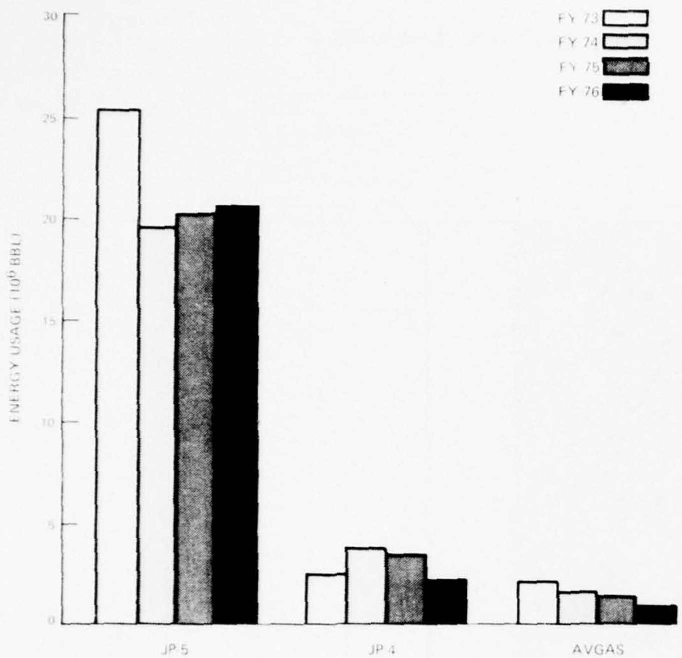


AIRCRAFT	PETROLEUM USAGE (10^{12} Btu)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
USN COMBAT	96.3	78.0	78.2	79.3	-19.0	-18.9	-17.7
USMC COMBAT	29.5	24.6	24.6	24.8	-16.6	-16.6	-16.1
TRAINING	18.1	15.5	14.9	14.0	-14.4	-17.7	-22.5
RESERVES	13.2	12.0	12.5	15.9	-9.1	-5.3	20.5
SUPPORT	10.3	8.9	8.6	9.2	-13.6	-16.5	-10.1
TOTAL	167.4	139.0	138.8	143.2	-17.0	-17.1	-14.5

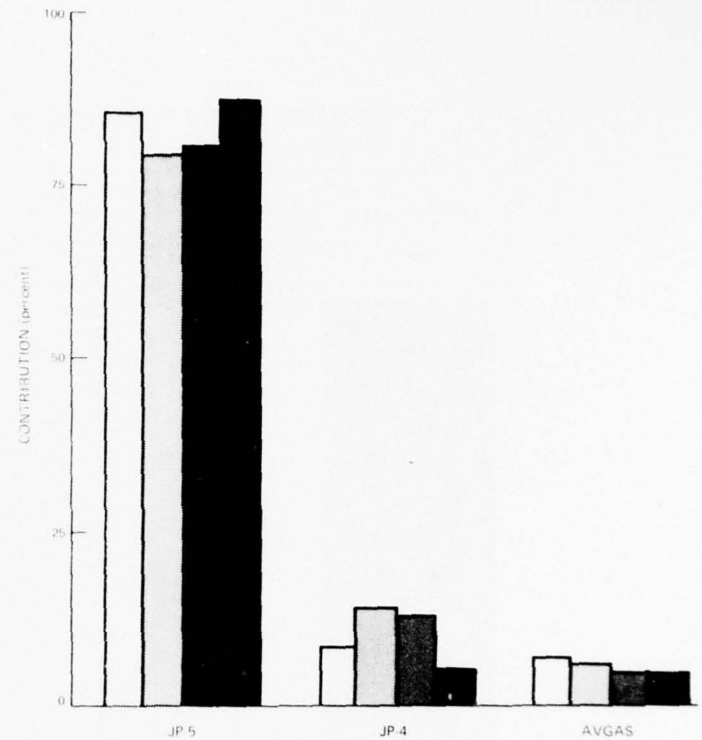


AIRCRAFT	CONTRIBUTION (percent)			
	FY 73	FY 74	FY 75	FY 76
USN COMBAT	57.5	56.1	56.4	55.3
USMC COMBAT	17.6	17.7	17.7	17.3
TRAINING	10.8	11.1	10.7	9.8
RESERVES	7.9	8.7	9.0	11.1
SUPPORT	6.1	6.4	6.2	6.5

Figure A-10. PETROLEUM USAGE BY AIRCRAFT

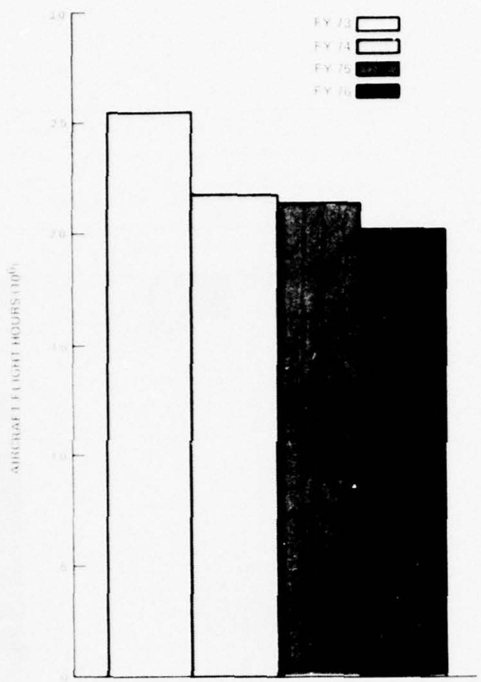


FUEL	PETROLEUM USAGE (10^6 BBL)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
JP 5	25.2	19.5	20.1	22.7	-22.6	-20.2	-9.9
JP 4	2.5	3.8	3.4	1.6	52.0	36.0	-36.0
AVGAS	2.1	1.6	1.3	1.2	-23.8	-38.1	-42.9
TOTAL	29.8	24.9	24.8	25.4	-16.4	-16.8	-14.8

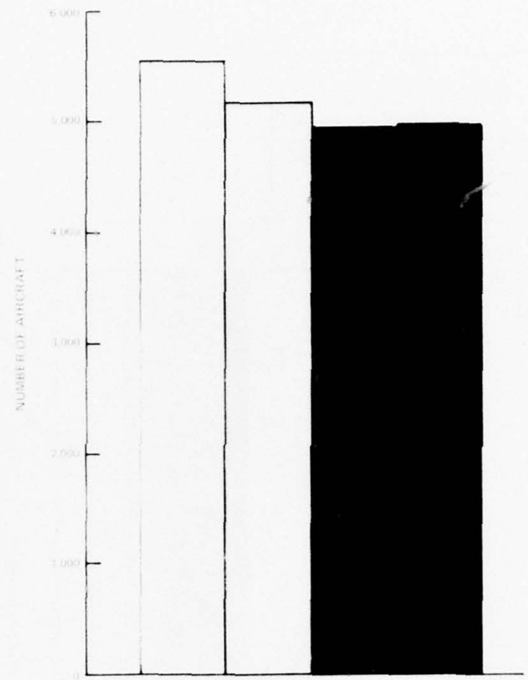


FUEL	CONTRIBUTION (percent)			
	FY 73	FY 74	FY 75	FY 76
JP 5	85.4	79.6	82.1	89.1
JP 4	8.0	14.5	13.1	6.3
AVGAS	6.6	5.9	4.8	4.6

Figure A-11. PETROLEUM USAGE FOR AIRCRAFT BY TYPE

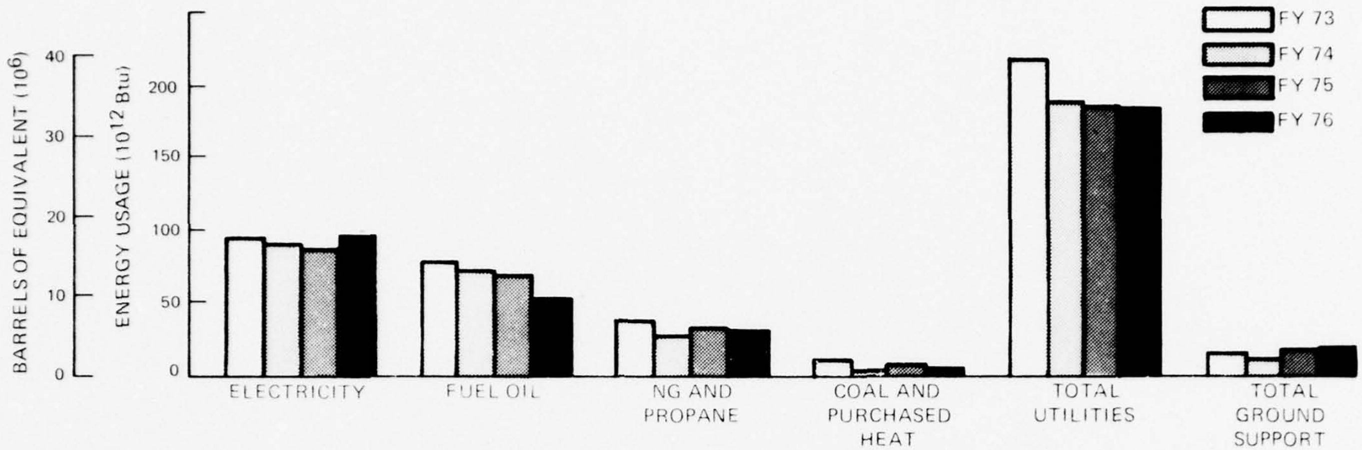


FLIGHT HOURS (10^6)				CHANGE (percent)		
FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
2.551	2.187	2.144	2.052	14.3	15.9	19.6



NUMBER OF AIRCRAFT				CHANGE (percent)		
FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
5,500	5,170	4,915	4,931	7.4	12.1	11.8

Figure A-12. AIRCRAFT ACTIVITY AS MEASURED BY FLIGHT HOURS



ENERGY FORM	ENERGY USAGE (10^{12} Btu)				CHANGE (percent)		
	FY 73	FY 74	FY 75	FY 76	FY 73-74	FY 73-75	FY 73-76
ELECTRICITY	95.8	90.6	89.6	94.8	−5.4	−6.5	−1.0
FUEL OIL	77.2	68.1	61.8	55.9	−11.8	−19.9	−27.6
NATURAL GAS AND PROPANE	34.8	26.5	30.3	29.1	−23.9	−12.9	−16.4
COAL AND PURCHASED HEAT	5.8	3.4	4.1	3.7	−41.4	−29.3	−36.2
TOTAL UTILITIES	213.6	188.6	185.8	183.4	−11.7	−13.0	−14.1
TOTAL GROUND SUPPORT	14.1	11.5	15.1	15.3	−18.4	7.1	8.5
TOTAL	227.7	200.1	200.9	198.7	−12.1	−11.8	−12.7

Figure A-13. SHORE ENERGY USAGE BY ENERGY FORM

APPENDIX B

NAVY ENERGY R&D PROJECTS AND PROGRESS

1.0 INTRODUCTION

This appendix describes Navy energy R&D projects, progress, and funding in six sections:

- Energy conservation
- Synthetic fuels
- Energy self-sufficiency
- Energy-related support
- Energy management and analytical support
- Funding.

Each of the first four sections discussed above is further subdivided into research, development, test, and evaluation (RDT&E) categories and shows the responsible Navy management units. Line drawings, similar to Figure B-1, will be used throughout this appendix to show the area of work under discussion at the time.

The Department of the Navy RDT&E Management Guide, dated 1 January 1975, gives the following definitions for RDT&E categories.

Category 6.1, Basic Research—Includes scientific study and experimentation toward increasing knowledge and understanding in the physical, engineering, environmental, biological/medical, and behavioral/social sciences fields that is related to long-term national security needs; provides fundamental knowledge for the solution of identified military problems; and provides part of the base for subsequent exploratory and advanced developments in defense-related technologies and new or improved military functional capabilities.

Category 6.2, Exploratory Development—Includes all effort toward solving specific military problems, but not major development projects. This type of effort may vary from fairly fundamental applied research to quite sophisticated hardware studies, programming, and planning efforts. This category of effort is directed toward specific military problem areas to develop and evaluate the feasibility and practicability of possible solutions and their parameters. Program control is normally by a general level of effort.

Category 6.3, Advanced Development—Includes all projects that have moved into the stage of hardware development for experimental or operational test, and is characterized by line-item projects and the design of hardware items for test or experimentation, as opposed to items designed and engineered for eventual Service use. Program control is exercised on a project basis.

Category 6.4, Engineering Development—Includes the development programs being engineered for Service use, but which have not yet been approved for procurement or

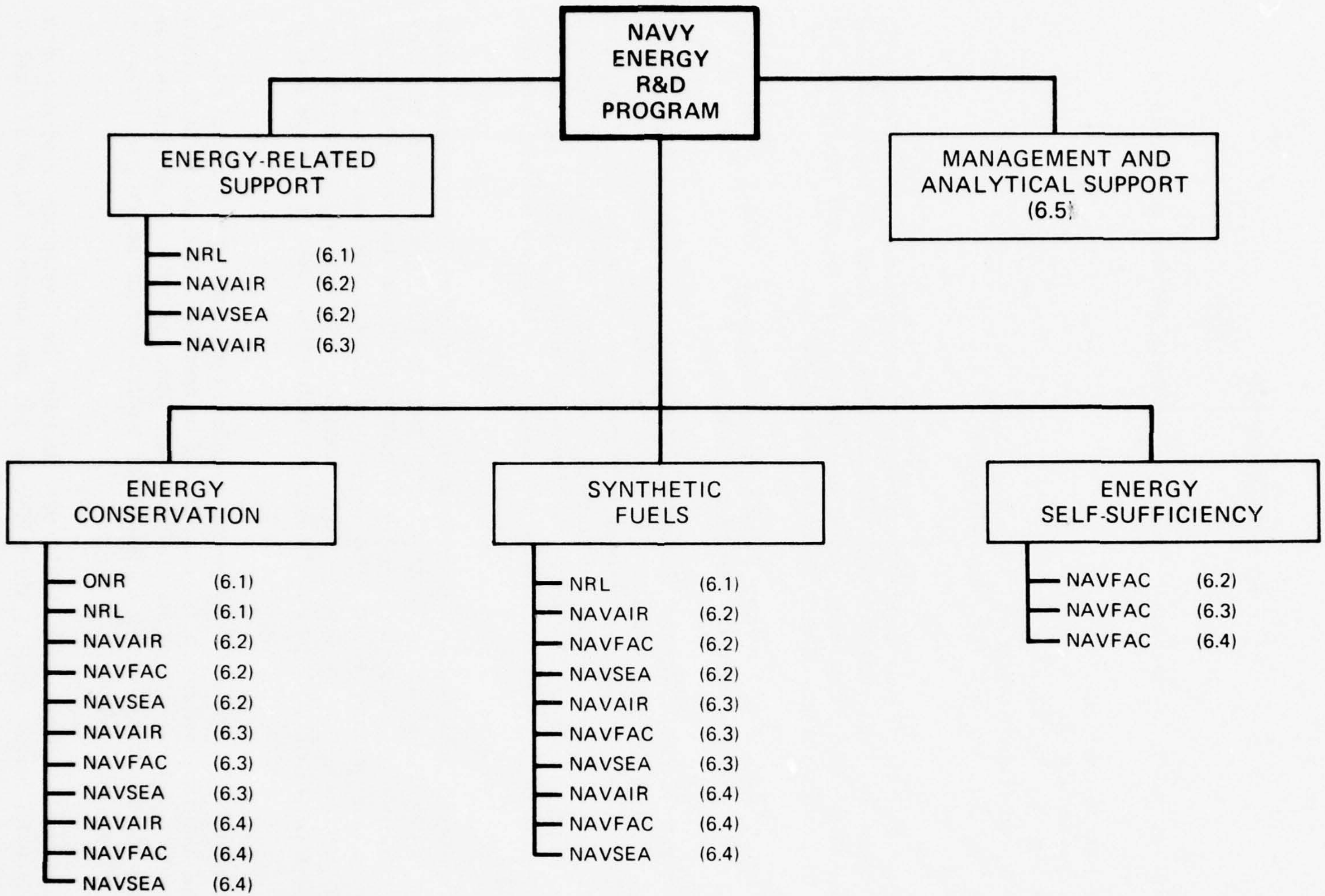


Figure B-1. PROGRAM ORGANIZATION GUIDE

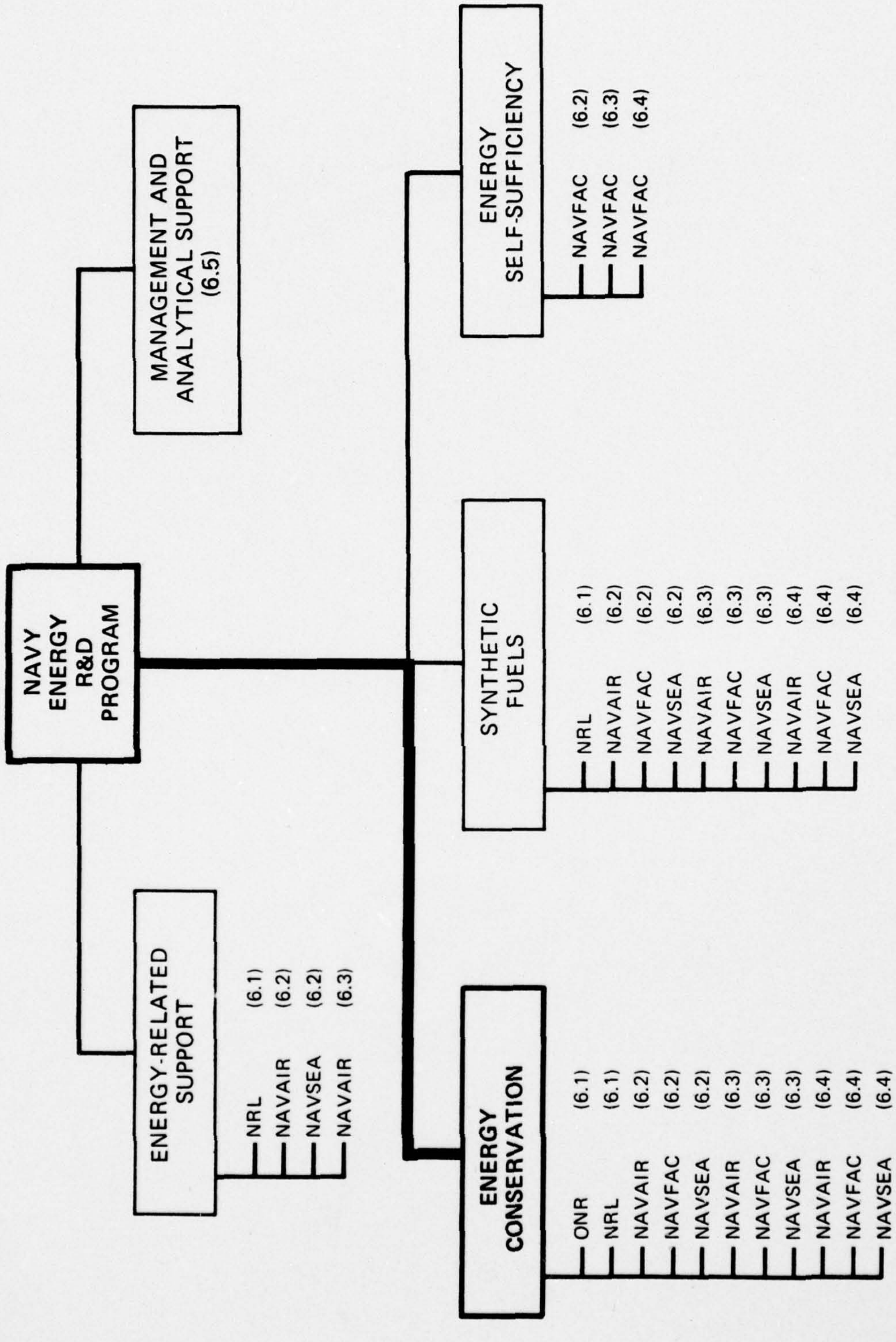
operation, and is characterized by major line-item projects. Program control is by review of individual projects.

Category 6.5, Management and Analytical Support—Includes research and development effort toward support of installations or operations required for general research and development use. Included are test ranges, military construction, maintenance support of laboratories, operations and maintenance of test aircraft and ships, and studies and analyses in support of the R&D program.

Category 6.1, basic research, and Category 6.2, exploratory development, are block programmed and administered by the Chief of Naval Research and the Chief of Naval Material, respectively. The System Commands (SYSCOMs) and laboratories are normally responsible for planning and executing work under Category 6.2. The Director of the Navy Energy R&D Office (MAT-08T3) administers and controls the block funding for Category 6.2 energy conservation work performed at the Civil Engineering Laboratory (CEL). Advanced development (6.3) and engineering development (6.4) programs are performed under the direction of the Director, RDT&E (OP-098). Energy matters in these categories are supervised by the Chief of Naval Material and his Director, Navy Energy R&D Office (MAT-08T3), who authorize the implementation of energy projects at the SYSCOM. Energy management and analytical support (6.5) projects are supervised by MAT-08T3.

ENERGY CONSERVATION

ENERGY CONSERVATION


NAVY ENERGY R&D PROGRAM
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
ENERGY CONSERVATION
ONR (6.1)
NRL (6.1)
NAVAIR (6.2)
NAVFAC (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
NAVFAC (6.3)
NAVSEA (6.3)
NAVAIR (6.4)
NAVFAC (6.4)
NAVSEA (6.4)
SYNTHETIC FUELS
NRL (6.1)
NAVAIR (6.2)
NAVFAC (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
NAVFAC (6.3)
NAVSEA (6.3)
NAVAIR (6.4)
NAVFAC (6.4)
NAVSEA (6.4)
ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
NAVFAC (6.3)
NAVFAC (6.4)

2.0 ENERGY CONSERVATION

2.1 INTRODUCTION

Conservation is the only near-term possibility to reduce the cost and increase the availability of energy sources. Therefore, conservation has received immediate and continual attention by the Navy Energy R&D Office.

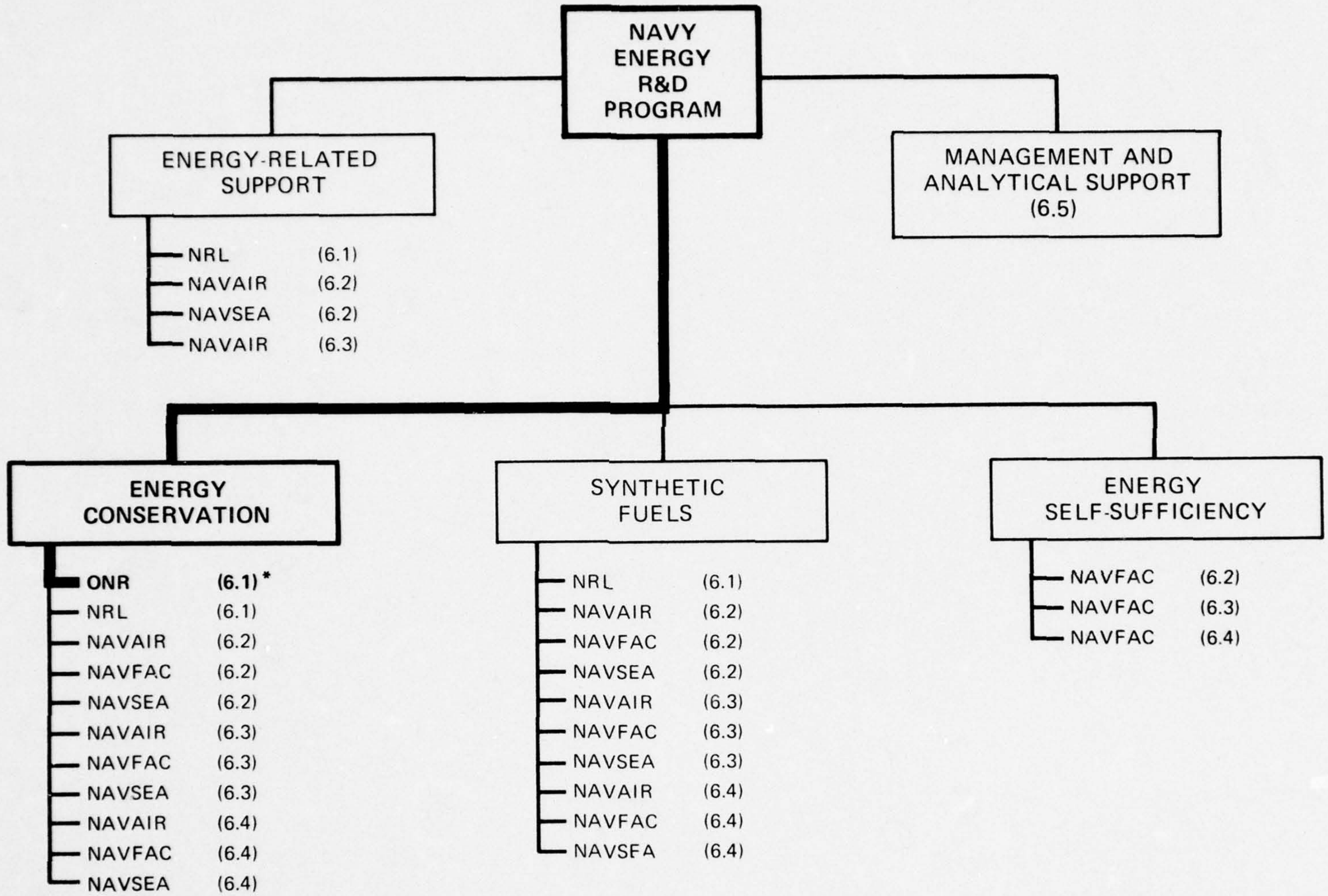
Rigid energy conservation goals are not possible. Energy can always be saved, for example, by stopping operations. If the fleet is anchored and aircraft grounded, however, their effectiveness, purchased and maintained at great cost, is lost. Therefore, reducing energy consumption must be accomplished without reducing the readiness and overall cost-effectiveness of the Navy.

The primary thrust of the Navy R&D effort in conservation is:

- Developing and implementing new technologies or operational practices that will reduce energy consumption by eliminating losses now incurred without losing effectiveness.
- Developing new propulsion and auxiliary machinery that has higher basic efficiency expectations than the systems now used.

In keeping with the policy recommendations of the Defense Energy Task Group (DETG), the Navy Energy R&D Office has concentrated on energy conservation aboard ship and at shore installations. The lead DOD agency for aircraft fuel conservation is the Air Force.

ENERGY CONSERVATION
BASIC RESEARCH (6.1)
ONR



*ENERGY SUPPORT ADMINISTERED BY ONR

2.2 BASIC RESEARCH (6.1)

2.2.1 Office of Naval Research (ONR) Energy Conservation

Introduction

ONR Category 6.1 energy programs are related to more efficient ship propulsion. Outlines of these work units are given on the following pages. Programs with no reported progress are new efforts. Planned milestones are not listed because of the basic nature of the research. The work units that may have the most immediate impact on energy consumption relate to tribology. ONR, the Energy Research and Development Administration (ERDA), and the American Society of Mechanical Engineers jointly sponsored a workshop to identify and quantify the future potential energy savings to the nation achievable by selectively accelerating tribology research and development. The analysis of the workshop findings shows that a potential energy savings of 6 percent of the total U.S. energy consumption is possible with the majority (4 percent) of the savings achievable in the short term by improving the technology of internal combustion engines and continuously variable ratio traction power transmissions. Specific program thrusts include reductions in piston-cylinder energy losses, acceleration of the fundamental of fluid film traction and the related materials technology, evaluation of low-viscosity lubricants from the standpoint of equipment survivability, and development of high-temperature adiabatic diesel technology. The Navy's Category 6.1 program is the base from which many of these thrusts will be made. In particular, Navy research in fluid traction fundamentals and surface behavior (wear particle analysis) is of crucial importance.

The series of work units on nuclear ship propulsion (less reactors) constitutes an effort to produce closed-cycle magnetohydrodynamic (MHD) generators that could increase power plant efficiencies while simultaneously greatly simplifying propulsion machinery.

Conservation
Category 6.1
ONR

Naval Vehicle Design and Construction:
High-Pressure Liquid Viscosity

P.E. 61153N
Task Area RR 023-01-82
Work Unit: 229-007

Objective

The objective of this work is to evaluate a technique based on auto-correlation technology to measure the time and pressure dependencies of liquid viscosity. The work is relevant to the Navy's need of improving the reliability of naval machinery, in explaining the shock sensitivity of liquid explosives to premature detonation, and in guiding the synthesis of high energy-high density low-viscosity missile fuels.

Technical Approach

The approach is to measure the time dependence of thermally driven density fluctuations and to relate these quantities via established equations to the time, pressure, and temperature dependencies of shear viscosity.

FY 1976/77 Progress

Research (in a 50 percent substituted methylsiloxane fluid) has shown that light scattering provides a nearly ideal method for probing the viscoelastic relaxation spectrum of polymers; the identification and measurement of those relaxational modes that are characteristic of polymer fluids, i.e., those modes associated with flexing the coiling of the molecular backbone, can be rather straightforwardly accomplished without the necessity for assuming some sort of reduction scheme of superposing data taken at different pressures and temperatures.

Conservation
Category 6.1
ONR

Naval Vehicle Design and Construction: Adhesive and Fatigue Wear Particle Production Rates

P.E. 61153N
Task Area RR 023-01-82
Work Unit: 229-012

Objective

The objective of this research is to determine the rates of production of adhesive and fatigue generated wear particles in lubricated systems as a function of applied load, speed, and material. This knowledge will be beneficial in developing methods to detect incipient failure in naval mechanical systems.

Technical Approach

Wear particle production rates will be determined as a function of speed, load, material, and test time. Changes in wear particle size, shape, and size distribution will also be noted.

FY 1976/77 Progress

Simple heating procedures have been devised that make it possible to distinguish the class of materials from which the particulates are generated. For example, it is possible, by thermal treatment of the particulates, to identify particles of low alloy steels, cast iron, stainless steels, and alloyed steels, and to distinguish brass particles from bronze particles. These simple techniques will make it possible to more accurately pinpoint the site of abnormal wear in a machine.

Conservation
Category 6.1
ONR

High-Pressure Viscosity Measurement

P.E. 61153N
Task Area RR 023-01-82
Work Unit: 229-015

Objective

The objective of this work is to determine the influence of molecular structure on the time-dependent viscosity and density response of liquids and other viscoelastic materials. This data is needed in the design and development of rolling element bearing and gears for high load-high speed applications in equipment such as gas turbines and helicopter transmissions.

Technical Approach

The approach will be to measure densities and viscosities of the subject lubricants as a function of time at pressures up to 500,000 psi using the micro high-pressure optical viscometer and to correlate these properties with similar work at Catholic University.

FY 1976/77 Progress

The results to date show that (1) fluid can support a certain shear stress no matter how fast it is sheared and this stress cannot be exceeded; (2) viscosity is not a function of pressure after a critical viscosity is reached; (3) this critical viscosity is a function of time that liquid is under the pressure.

Conservation
Category 6.1
ONR

Mechanism of Heat Generation in Elastohydrodynamic Contacts

P.E. 61153N
Task Area RR 023-01-82
Work Unit: 229-018

Objective

The objective of this research is to determine the magnitude of the temperature rise accompanying the compression of lubricants in bearing and concentrated contacts. This data is necessary to develop machine design methodology necessary to specify lubricants and operating envelopes of high-performance machinery systems.

Technical Approach

In the second year, the pressure and temperature experiment will be conducted with several lubricants for a wide range of conditions. Theoretical analyses will include an evaluation of the effect of inlet zone and compression heating temperatures. This information will be used to assess the irreversibilities of the compressional and inlet heating process as the speed of compression is varied. The result of this overall project will result in a greatly enhanced state-of-the-art for understanding elastohydrodynamic (EHD) temperature and the ramification of these temperatures in the EHD process.

FY 1976/77 Progress

A special transducer has been developed so that pressure and temperature measurements can be made (essentially) simultaneously. With this technique, it is possible to locate the contact zone temperatures relative to pressure to evaluate the relationship between heat generation and pressure. Temperature pressure data obtained using a synthetic mineral oil lubricant has been obtained for rolling and rolling-sliding contact in a special disk apparatus. Temperature increases of 10° C to 20° C have been detected. Traction analyses indicate, in some instances, that this level of temperature increase can explain the nonlinearity seen in traction-slip curves.

Conservation
Category 6.1
ONR

Material Support Technology:
Wear Reduction in Sliding Systems

P.E. 61153N
Task Area RR 024-03-02
Work Unit: 097-396

Objective

The objective of this research is to discover the mechanism by which a complex metal chalcogenide (arsenic thioantimonate) provides a 300 to 400 percent improvement in wear resistance when compared to molybdenum disulfide. Molybdenum disulfide is the solid lubricant used in most naval solid lubricants.

Technical Approach

Variables, such as the chemistry and surface finish of hard and soft materials, sliding velocity, normal load, and lubricant, will be investigated. Hard materials will be spherical; soft members will be flat.

FY 1976/77 Progress

Under certain conditions, carbon tetrachloride is found to be a negative boundary lubricant (it gives a higher coefficient of friction than that of dry surfaces in air), while under other conditions, it lowers friction and has a beneficial effect. Both of these situations have been illustrated for heavily loaded sliding surfaces where the subsurface is undergoing gross plastic flow and an explanation has been presented which appears to be consistent with all experimental facts. Carbon tetrachloride is found to be more reactive chemically when the sliding surfaces are heavily strained or galled under high normal and shear stresses and containing microcracks, a situation that occurs when cutting at low speed.

Conservation
Category 6.1
ONR

Material Support Technology: High-Pressure Liquid Properties Relevant to Lubricants and Explosives

P.E. 61153
Task Area RR 024-03-02
Work Unit: 007-397

Objective

A theoretical understanding is sought of the time-dependent changes in properties of liquids subjected to high pressures. Of concern are the nonlinear property changes during nonequilibrium conditions. Such phenomena are applicable to the behavior of lubricants under conditions of high loading and to the sensitivity of energetic materials.

Technical Approach

Fluid property changes are experimentally induced by temperature changes. Relaxation times associated with various property changes, including specific heat, refractive index, and volume, will be determined. A theoretical model will be formulated on the basis of these and subsequent experiments.

FY 1976/77 Progress

The influence of measurable fluid properties on the dynamic shear stress in rapidly loaded materials has been evaluated. The relative sensitivities of the shear stress to changes in the fluid properties, for example, the distribution of shear relaxation times, have been established.

Conservation
Category 6.1
ONR

Frictional Wear Mechanisms: Machinery Wear Technology

P.E. 61153N
Task Area RR 024-03-02
Work Unit: 097-398

Objective

The effects of localized heat conductivity, temperatures, and pressures on wear mechanisms that take place between solid materials in sliding contact are being investigated. The investigations include the effects of thin liquid surface films and surface features such as nonflatness, asperities, and patches of contact. These investigations will lead to an improved understanding of wear mechanisms with subsequent improvement in naval machinery design and performance.

Technical Approach

Analytical models of wear mechanisms are being developed which account for the parameters and surface features stated above. Experimental data are being acquired, including temperatures, rotational speed, and torque measurements.

FY 1976/77 Progress

A concept of critical wear rate has been developed. Contact stability has been related to it.

Conservation
Category 6.1
ONR

Self-Generated Electromotive Force in Sliding Systems

P.E. 61153N
Task Area RR 024-03-02
Work Unit: 097-399

Objective

The objective is to determine the interrelationship between metallurgy, chemistry, and environment that controls the rate of wear in Navy mechanical equipment. Wear control is important in improving the reliability and extending the overhaul life of a wide variety of Navy lubrication and hydraulic systems.

Technical Approach

The phenomena of wear-induced electromotive force (EMF) generation will be investigated to unravel the relationship between the rate of wear and chemical processes occurring between lubricant molecules or chemically reactive intermediates and the wearing surfaces. This will be used to improve understanding of chemically induced surface fatigue processes and may provide a means to prevent their occurrence.

FY 1976/77 Progress

It has been demonstrated that EMFs are generated under boundary lubricated conditions. Under several conditions, it has been possible to relate the wear process to the self-generated EMFs. Under others it has not, presumably because other variables, such as lubricant type, temperature, and environmental atmosphere, in addition to wear, control the magnitude and polarity of the self-generated EMFs.

Conservation
Category 6.1
ONR

Naval Vehicle Design and Construction: Tribology Planning Study Detailing Technical Approaches Toward the Goal of Energy Conservation

P.E. 61153N
Task Area RR 024-03-02
Work Unit: 097-416

Objective

The objective is to develop a research plan aimed at accelerating the development of tribology. Tribology is a science and technology that, when developed and implemented, will simultaneously conserve energy and reduce maintenance costs of civilian and military mechanical equipment.

Technical Approach

The approach is to assess the state-of-the-art in the fields of fluid film traction, process fluid lubrication, and friction and wear reduction in reciprocating machinery; identify research requirements; determine the status of research underway; and identify research program deficiencies.

FY 1976/77 Progress

The tribology workshop was held 7-9 February 1977. Workshop recommendations are being prepared.

Conservation
Category 6.1
ONR

Nuclear Ship Propulsion (less reactors)
Liquid Metal Magnetohydrodynamic (MHD) Power Generation (U. of the Negev)

P.E. 61153N
Task Area RR 024-01-01
Work Unit: 099-407

Objective

The objective of this study is to experimentally examine turbulence in liquid metal MHD generators in strong magnetic fields to determine the capability of the liquid metal MHD generation to meet the Navy's future power needs.

Technical Approach

A test facility consisting of a mercury circulating loop with an azimuthal magnetic field in the test section has been constructed. The main measuring apparatus is a hot wire (film) anemometer and thermocouple system for heat transfer measurements. The test section is specifically designed to investigate the nature of the transition from laminar flow to turbulent flow in MHD generators.

FY 1976/77 Progress

Test loop construction and the preliminary tests of the apparatus have been completed. Detailed measurements of the integral hydraulic and electric characteristics of the MHD channel are complete and being analyzed.

Planned Milestones (Completion Dates)

May 1978—Complete annual report.

Conservation
Category 6.1
ONR

Heat Transfer Problems in Advanced Gas Turbines

P.E. 61153N
Task Area RR 024-03-02
Work Unit: 097-383

Objective

The objective of this effort is to achieve the capability to predict the fluid flow and heat transfer that affect gas turbine performance. Particular attention is given to such heat transfer processes as impingement and film cooling.

Technical Approach

Both theoretical and experimental investigations in heat transfer and fluid dynamics are conducted with attention focused on various methods of cooling such as impingement, film transpiration, and convection.

FY 1976/77 Progress

Experimental studies of film cooling have progressed to include multiple rows of holes. Flow visualization studies continued with varying cavity geometry. The laser-doppler-velocimeter instrumentation was improved and used to measure turbulence.

Planned Milestones (Completion Dates)

October 1977—Complete annual report.

Conservation
Category 6.1
ONR

Advanced Topping Cycles
Convective Heat Transfer for Ship Propulsion Systems

P.E. 61153N
Task Area RR 024-03-02
Work Unit: 097-395

Objective

This study is to research thermodynamics and fluid dynamics concerning convective heat transfer in gases, appropriate to the closed Brayton cycle and applicable to marine propulsion and power systems.

Technical Approach

Experiments are carried out to determine the effects of heating rates and mixture composition and other properties on convective heat transfer for low Prandtl number gases, such as mixtures of helium and xenon, applicable to the closed Brayton thermodynamic cycle. Data acquired will be used to extend and refine theories and analytic capabilities.

FY 1976/77 Progress

Analytic calculations were performed and compared to available experimental values of thermal conductivities and viscosities for helium, argon, xenon, and their binary mixtures. Values predicted by the Lennard-Jones model ranged 5 percent to 12 percent lower than the experimental values. Several analytical techniques are being studied with respect to their accuracy in predicting the convective heat transfer properties of low Prandtl number binary gas mixtures under simple flow conditions. Experimental heat transfer and pressure drop test equipment is being checked out and data reduction codes are being developed.

Planned Milestones (Completion Dates)

May 1977–Complete annual report.

Conservation
Category 6.1
ONR

Improved Efficiency Conventional Power Plants:
Ceramics for High-Temperature Heat Exchangers

P.E. 61153N
Task Area RR 024-03-02
Work Unit: 097-401

Objective

The objective is to investigate the properties of ceramics to determine their suitability for applications to high-temperature heat exchangers for shipboard propulsion systems. Crack growth rate in the 1600° F to 2400° F temperature range will be studied.

Technical Approach

Experiments on the crack growth rate of ceramics, including silicon carbide, are being conducted under static and dynamic loading conditions using methods that include double torsion.

FY 1976/77 Progress

Slow crack growth rate data are being experimentally obtained for siliconized silicon-carbide (Super KT).

Planned Milestones (Completion Dates)

March 1977–Complete annual report.
1977–Complete studies of Super KT. Initiate studies of sintered SiC.

Conservation
Category 6.1
ONR

Liquid Metal MHD Power Generation (Argonne)

P.E. 61153N
Task Area RR 024-01-01
Work Unit: 099-404

Objective

The objective is to experimentally and analytically examine the behavior of two-phase MHD generators to be used for propulsion.

Technical Approach

An experimental sodium potassium nitrogen loop is being operated to determine the effect of velocity and void fraction on generator performance. The value of surfactants for mixture control will be determined and analytical modeling improved.

FY 1976/77 Progress

Slip losses have been shown to be small as mixture velocity is increased. Some surfactants that show promise have been identified.

Planned Milestones (Completion Dates)

September 1977–Complete annual report.

Conservation
Category 6.1
ONR

MHD Flow Investigation

P.E. 61153N
Task Area RR 024-01-01
Work Unit: 099-412

Objective

The objective is to analyze two-phase Hartmann flows as applied to the Faraday MHD generator to provide information on the feasibility and practicability of two-phase MHD for naval propulsion.

Technical Approach

The approach is to conduct analytical studies of one-dimensional Hartmann flow in rectangular channels of finite aspect ratio having two insulated walls and two thin walls of finite conductivity representing electrodes, two-dimensional Hartmann flow in rectangular channels of finite aspect ratio having two insulating walls and two thin walls of finite conductivity representing electrodes, and compressible one-dimensional isothermal MHD flow with zero slip between its liquid and gas components.

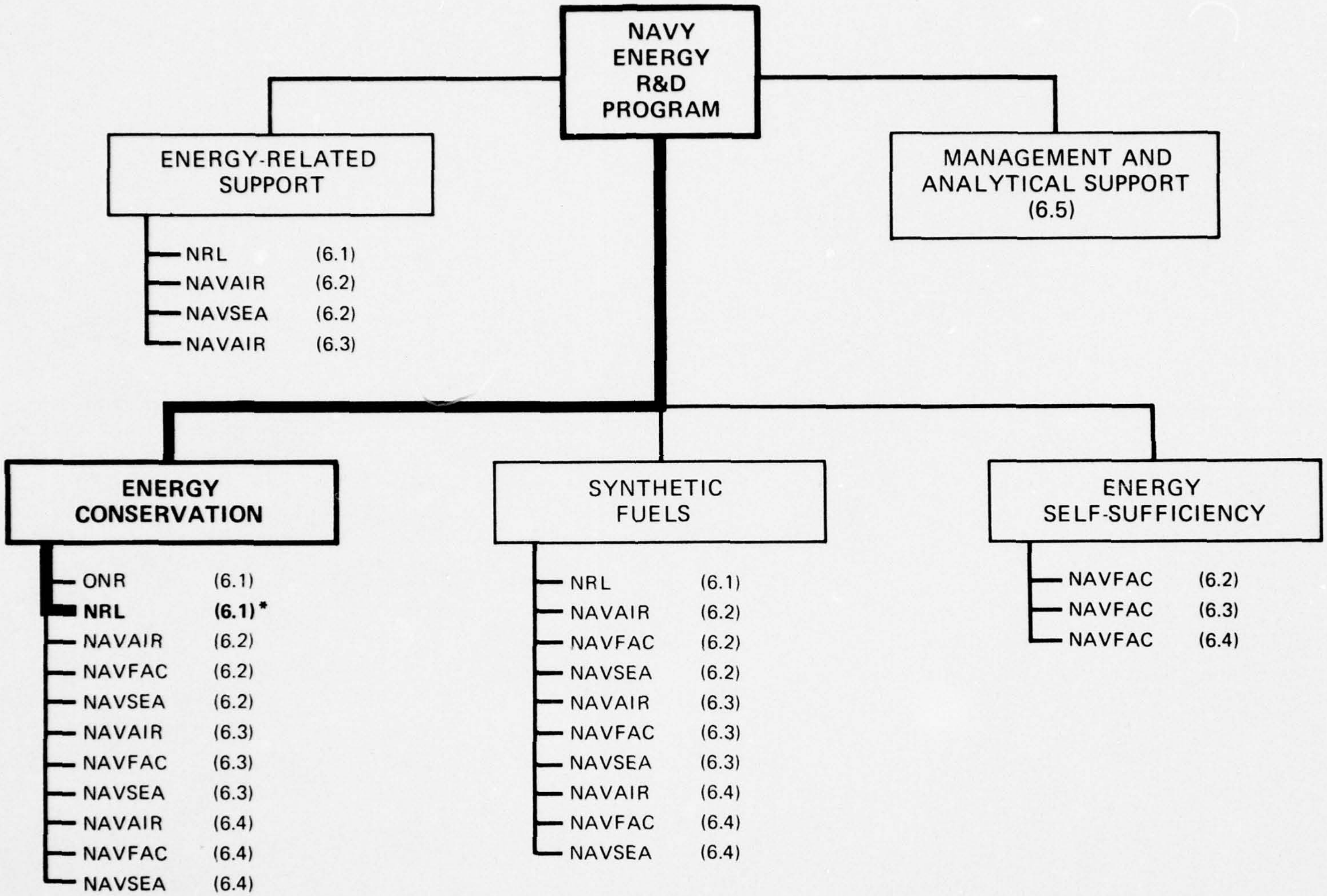
FY 1976/77 Progress

Analysis has determined that conductivity gradients can produce inflected velocity profiles and that, for larger load factors, the shunt current in the Hartmann boundary layers become considerable.

Planned Milestones (Completion Dates)

January 1978—Complete annual report.

ENERGY CONSERVATION
BASIC RESEARCH (6.1)
NRL



*ENERGY SUPPORT ADMINISTERED BY ONR

2.2.2 Naval Research Laboratory (NRL) Energy Conservation

Introduction

The NRL basic research energy programs relating to conservation are concerned with more efficient ship propulsion and combining chemical dash power and nuclear cruise power systems. The work units all have multiple applications. Most of the programs are well established efforts and all have carefully planned milestones.

Conservation
Category 6.1
NRL

Research on Properties of Materials at Ultra-Low Temperatures for Use with Turbine Driven Superconducting Generator Motor Propulsion Systems

P.E. 61153N
Task Area RR 011-02-42
Work Unit: P05–02.101

Objective

The objective is to determine the basic interactions in solids that control the electrical and magnetic properties of the solids, in particular those interactions responsible for superconductivity. The physical and chemical parameters that optimize superconductivity are sought.

Technical Approach

Samples of potentially important alloys are being studied. Physical properties such as magnetic moment, magnetic susceptibility, and resistivity are being determined as functions of temperature, pressure, and magnetic field intensity.

FY 1976/77 Progress

Superconducting wires containing 30 filaments of V_3Ga, fabricated under NRL Problem 64M01-43, were measured in magnetic from 6 to 13 tesla and at temperatures from 4.2 to 12K. These wires are very promising for use in electrical power generation and conversion. Neutron irradiation studies of V_3Ga bulk samples and of subsequent annealing effects are in progress. Eight new superconducting compounds of the Ti_3P crystal structure have been discovered. Pressure effect studies on V_3Ga indicate a unique change in the superconducting properties of this compound at modest pressures (less than 10 kb).

Planned Milestones (Completion Dates)

March 1977–Complete interim report on V_3Ga wires.
June 1977–Complete initial phase of radiation damage and annealing study on bulk V_3Ga.
July 1977–Complete pressure effect study an $AuGa_2$.
September 1977–Complete major synthesis efforts on Nb_3Ge.
October 1977–Complete pressure work at He^3 temperatures on $AuIn_2$, $AuAl_2$.
FY 1978–Continue radiation damage and synthesis work. Evaluate commercial V_3Ga wires. Continue pressure effect studies.

Conservation
Category 6.1
NRL

Improved Efficiency Conventional Power Plants: Diesel and Steam Surface Studies for Energy Converters

P.E. 61153N
Task Area RR 021-03-46
Work Unit: R08-78.101

Objective

Energy states just above the vacuum level and the effect that they have on strong incoming electrons are of specific importance in the collection efficiency for low-energy electrons in thermionic energy converter collection systems. The objective of this investigation is a study of the cause of these reflections and how they are influenced by the deposition of adatoms. The results will not only provide valuable basic information regarding the semiconductor band structure at the surface but also provide information regarding the development of surfaces for the optimized collection of electron emitters for microwave tubes which are more resistant to poisoning by adatoms.

Technical Approach

The approach will be to use surface techniques (low-energy electron probing scan, Auger electron spectroscopy, low-energy electron defraction, sputter profiling, attenuated and total optical reflection) combined with in-situ evaporation and film fabrication to study basic mechanisms, including atomic dipoles, surface states, interfacial analysis, and surface potential characteristics.

FY 1976/77 Progress

Recent results in this area have led to the development of a new technique that utilizes low-energy electrons incident on a surface and the subsequent analysis of the low-energy electron reflection (LEER) pattern that is obtained from it. Good agreement was found between the LEER analysis of BaO films using a kinematic approximation and the results from measured LEER lattice spacing. The work function of the surface was also separated to measure surface dipole effects involving the electron affinity as well as simultaneously determining the location and observing the factors which influence the position of the conduction band edge.

Planned Milestones (Completion Dates)

FY 1977-78–Complete study of surface dipole effects and bulk semiconductor effect from LEER measurements of stoichiometric defects in alkaline earth oxides.
FY 1978-79–Continue studies to develop materials for more reliable low work function surfaces.

Conservation
Category 6.1
NRL

Properties and Engineering Application of Thermostructural Materials

P.E. 61153N
Task Area RR 022-11-41
Work Unit: M01-14.101

Objective

The objectives are to gain an understanding of the mechanical behavior of thermostructural alloys under high-temperature conditions representative of service in Navy energy systems and to define the principles that govern behavior to serve as guides for better and more efficient utilization of the alloys. Another aim is to develop criteria for predicting metal performance, which would contribute toward greater reliability of components in service.

Technical Approach

The approach is to investigate the processes that lead to failure, such as crack propagation, crack initiation, and creep, using current and advanced materials (Ti alloys, stainless steels, superalloys, and refractory alloys). The loading modes include static, cyclic, thermal cycling, and combinations of these. The role of environment and the applicability of fracture mechanics are assessed.

FY 1976/77 Progress

It was shown that a creep-fatigue interaction occurs in Inconel 718, which enhances crack propagation. For this alloy, the linear summation damage rule prediction was found to be unconservative for hold-time fatigue. It was demonstrated that, in some alloys, crack growth occurs as easily under static load as under cyclic load of the same peak value. A detailed theoretical model for creep crack growth was developed based on the presumption that crack growth occurs by the diffusion of vacancies along grain boundaries. A dislocation model to predict threshold stress intensity for fatigue crack growth was also developed. The fatigue crack growth rates of stainless steel were found to be unaffected by specimen thickness over a wide range.

Planned Milestones (Completion Dates)

FY 1977–Characterize creep and fatigue crack propagation in Udimet 700 at 850° C. Study fatigue crack propagation in a directionally solidified eutectic alloy at 1,000° C. Complete study of sustained load and fatigue crack growth in Ti-6A1-4V alloy as a function of temperature.

FY 1978–Study hold-time effects on fatigue crack growth in superalloys in impure

helium and vacuum. Investigate sensitivity of crack propagation to microstructure in nickel-base alloys. Study creep-fatigue crack growth in cast nickel-base alloy.

FY 1979—Investigate hot corrosion effects on crack propagation in superalloys. Conduct displacement-rate controlled tests for analysis of fracture mechanics parameters. Study thermal cycling effects on crack propagation.

Conservation
Category 6.1
NRL

Fundamental Study of Electrode Reactions

P.E. 61153N
Task Area RR 024-01-45
Work Unit: C05-13.101

Objective

The objective is to produce more powerful and efficient military batteries by finding electrode processes that can enhance performance and increase life by identifying and removing inhibiting processes. The applications include propulsion and load leveling for more efficient fuel utilization.

Technical Approach

The study of the effect of chemical and physical parameters on the properties of electrode materials is done by using equipment such as ESCA, auger, X-ray, and mass spectroscopy, and electron and scanning electron microscopy with EDAX and electrochemical techniques (such as perturbation and relaxation methods). Extensive computational analysis is carried out in conjunction with the experimental methods to optimize battery construction.

FY 1976/77 Progress

An image analyzer has been obtained and is being used to directly measure the extent of reactions at various depths within porous electrodes. Coupling of this instrument with an on-line computer is almost complete, and will allow measurement of reactivity as a function of particle size, shape, pore shape, etc.

Neutron diffraction analysis is being used to identify the chemical structure of the electrochemically active fraction that seems to be present in a variety of porous electrodes.

Planned Milestones (Completion Dates)

FY 1977—Complete report on AES and XPS studies of oxy/anions of sulfur and phosphorus.
FY 1978—Continue studies of kinetics of porous electrodes and of flow-through electrolyte systems.
FY 1979—Develop a comprehensive computer model of a real, porous electrode system.

Conservation
Category 6.1
NRL

High-Temperature and High-Pressure Chemistry Related to Improved Thermal Energy Conversion

P.E. 61153N
Task Area RR 02-403-41
Work Unit: CO5-26.101

Objective

The objective is to improve the performance, reliability, and energy efficiency of shipboard boilers, evaporators, and allied power systems through chemical reduction or elimination of corrosion, scaling, sludging, and other processes that inhibit heat transfer and limit performance.

Technical Approach

The high-temperature, high-pressure aqueous solution reactions that reduce corrosion, scaling, and sediments in boilers, evaporators, and associated systems are studied through spectroscopic and electrochemical methods, stopped-flow and other fast kinetic techniques. Special emphasis is placed on the means by which water treatment agents, dissolved gases, and organic and inorganic contaminants affect these reactions.

FY 1976/77 Progress

At the request of other Navy facilities, ERDA, and industry, the kinetics studies of reactions between water and organic and inorganic materials at high temperatures and pressures were extended to three new areas. The reactions of ethylenediaminetetraacetic acid with water at very low pH values were monitored by proton nuclear magnetic resonance spectroscopy; kinetic results indicate that the reactions in acid solution are much faster than in basic solutions, start at much lower temperatures, and produce products that may aid in rapidly cleaning surfaces of insulating scale or rust. In addition, the results indicate that the hydrolysis reactions may be utilized in a unique method for removing radioactive wastes from nuclear reactors without the loss of heavy water.

Another new investigative area is the study of organic particulates from ion exchange resins that react with water under extreme conditions. The soluble reaction products are being identified and their potential adverse effects on steam-generating plants, cooling systems, or other systems using demineralized water are being evaluated.

Lastly, in cooperation with the NRL Plasma Physics Division, methods are being investigated to study the chemistry of organic chelating agents in solution when suddenly exposed to high temperature for very short duration—a realistic approach to aqueous solutions suddenly being exposed to boiler hot-spots. One device provides the desired parameters by generating high-voltage pulses through interrupting the current in solutions

of varying organic chelant concentrations. In addition to determining the stability of the organic materials in solution, the results suggest ways to greatly improve the characteristics of fuses in an inductive circuit.

Planned Milestones (Completion Dates)

FY 1978—Test materials for improving the energy efficiency, performance, and reliability of Navy boilers, evaporators, and allied power systems in high-temperature and high-pressure environment. Study the kinetics of oxidation-reduction reactions that occur between various chelating agents and dissolved oxygen, using NRL-designed test apparatus.

FY 1979—Study photochemically induced reactions by selectively exciting chelated and unchelated species in aqueous solutions. Investigate photochemical reactions as an efficient means to remove unwanted organic chelating material from water.

Conservation
Category 6.1
NRL

Transfer and Storage for Thermal Power Systems for Use with Combined Chemical Dash Power and Nuclear Cruise Power Systems

P.E. 61153N
Task Area RR 024-01-45
Work Unit: E01-07.101

Objective

The objective is to develop an efficient, cost-effective closed cycle means to convert thermal energy to chemical energy and back to thermal energy in an energy storage-boiler facility after transport.

Technical Approach

The approach is to analyze theoretically energy recovery, transfer, and storage systems with emphasis on systems involving transport of energy in chemical form. Reactors for the conversion of thermal energy into chemical energy are designed, analyzed, and tested. Energy storage boiler tanks using eutectic fusion storage and heat pipe energy transfer between components are also designed and tested.

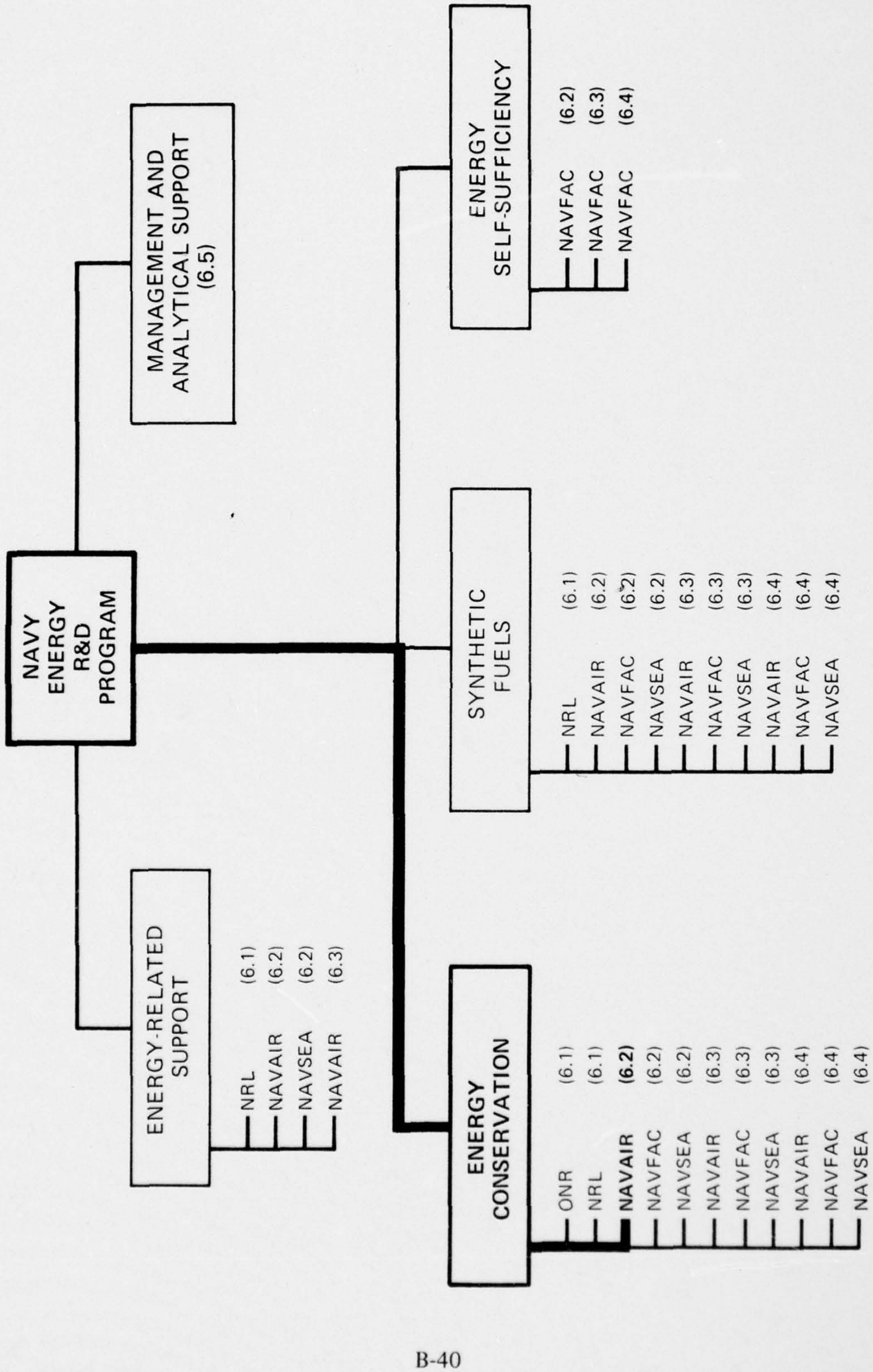
FY 1976/77 Progress

The feasibility of gas reforming methanation and sulfur oxide dissociation/recombination for energy recovery and transmission have been established analytically. A suitable thermal test facility was located to test the conversion of energy to chemical energy. Experimental work has been initiated on an energy storage-boiler tank using heat-of-fusion in sodium chloride, potassium chloride, and magnesium chloride eutectic and m-terphenyl heat pipe fluid for energy transfer. The design of material compatibility tests and melt-fusion cycle tests for the boiler tanks were completed and implemented. A 9-foot energy storage boiler tank, a reactor/heat exchanger for gas dissociation using nonmetallic counter/current heat exchanger, and a preliminary reactor-heat exchanger for gas dissociation using regenerator wheel heat exchanger were designed.

Planned Milestones (Completion Dates)

FY 1977—Carry out demonstration tests and continue development of the 9-foot energy storage boiler tank. Build or procure reactor/heat exchanger for use on WSMR thermal effects facility solar furnace. Carry out initial gas dissociation demonstration on WSMR thermal effects facility solar furnace.

ENERGY CONSERVATION
EXPLORATORY DEVELOPMENT (6.2)
NAVAIR


NAVY ENERGY R&D PROGRAM
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
ENERGY CONSERVATION
ONR (6.1)
NRL (6.1)
NAVAIR (6.2)
NAVFAC (6.2)
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NAVAIR (6.4)
NAVFAC (6.4)
NAVSEA (6.4)
SYNTHETIC FUELS
NRL (6.1)
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NAVSEA (6.4)
ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
NAVFAC (6.3)
NAVFAC (6.4)

2.3 EXPLORATORY DEVELOPMENT (6.2)

2.3.1 Naval Air Systems Command (NAVAIR)
Aircraft Energy Conservation
P.E. 62765N

Introduction

The Air Force is the lead DOD agency for aviation-related energy conservation programs. Therefore, NAVAIR has primarily a supporting role. NAVAIR will be starting a new task in FY 1978. An analysis will be made of the fuel used by current USN/USMC aircraft by aircraft type and mission. Using these data and the rework schedules for current inventory aircraft, possible design changes/modifications and/or mission operational changes will be evaluated to reduce fuel usage. Analyses of the projected fuel use of "advanced" systems concepts will also be undertaken.

Aircraft Fuel Conservation Analysis Program

Objective

The objective is to analyze the fuel used by USN/USMC aircraft by type and mission and study means to reduce fuel use by design changes/modifications and/or mission performance.

Technical Approach

Analyses will be made to identify the amount of fuel consumed by Navy and Marine aircraft by aircraft type and mission performed. Using these data, selected high fuel utilization aircraft that will be in the active inventory for 10-15 years will be studied for potential design changes (airframe, aerodynamics/propulsion, etc.) to reduce fuel usage. Compatibility and/or integration of proposed design changes with other scheduled rework or CILOPs must be considered.

Another portion of this task will be the comparison of energy usage by "advanced" systems concepts, new types of efficient air vehicles, and/or new concepts of operations that emphasize energy conservation.

These tasks are intended to be of a continuous nature. These projects are not intended to be "new discoveries," but rather to benefit/utilize other ongoing or proposed weapon systems analyses and studies with the emphasis on fuel conservation.

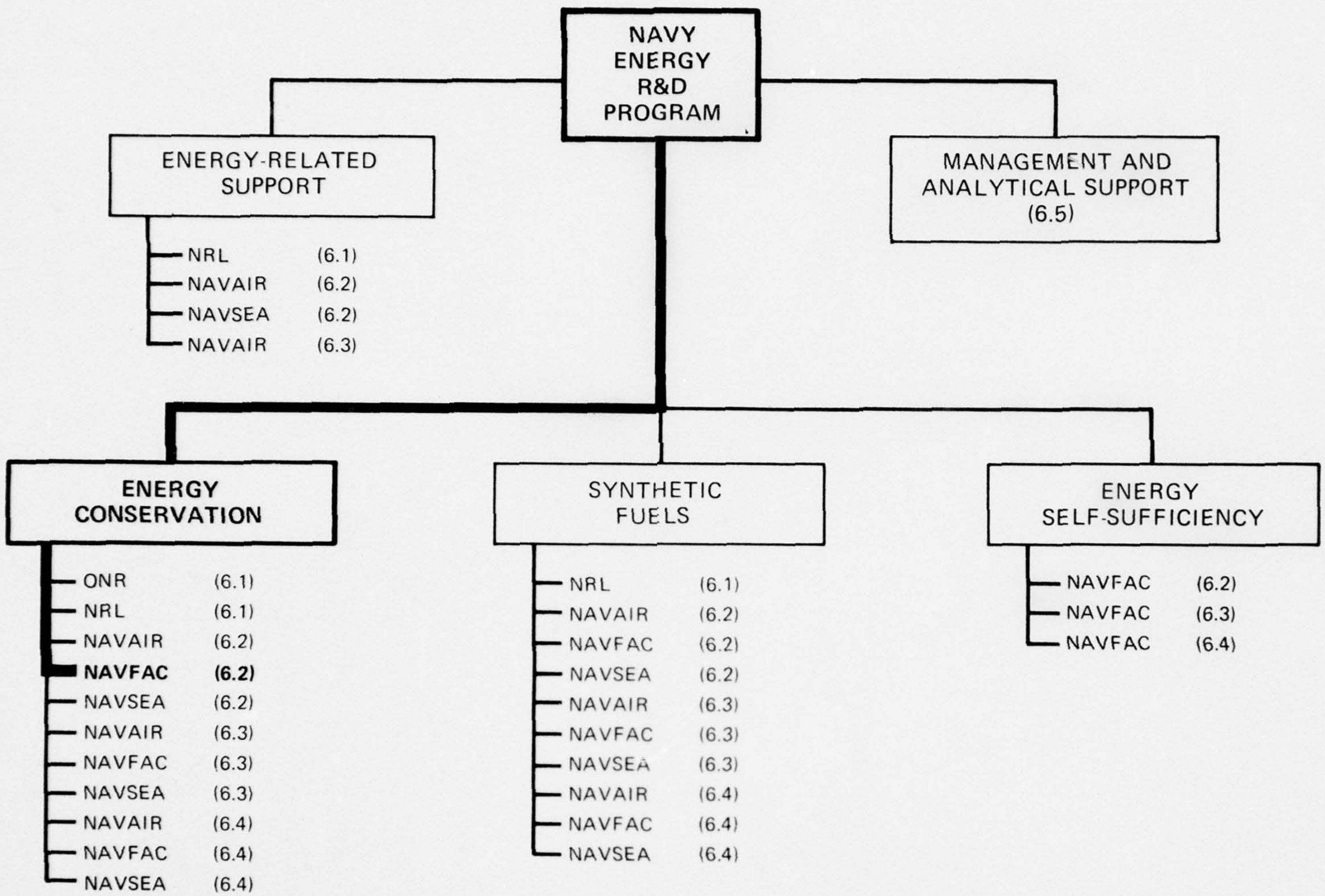
FY 1976/77 Progress

This project will be started in FY 1978.

Planned Milestones (Completion Dates)

July 1978–Present results (current inventory aircraft).
August 1978–Identify future (advanced concepts) energy use trends.

ENERGY CONSERVATION
EXPLORATORY DEVELOPMENT (6.2)
NAVFAC


NAVY ENERGY R&D PROGRAM
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY CONSERVATION
ONR (6.1)
NRL (6.1)
NAVAIR (6.2)
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SYNTHETIC FUELS
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ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
NAVFAC (6.3)
NAVFAC (6.4)

2.3.2 Naval Facilities Engineering Command (NAVFAC)
Shore Facilities Energy Conservation
P.E. 62765N
Task Area YF 57-571-001

Introduction

During FY 1975, the Navy shore establishment consumed energy equivalent to about 34 million barrels of oil. About 50 percent was for heating, ventilating, and air conditioning (HVAC), and for lighting, which represented an expenditure of about $188 million. In FY 1976, the Navy's energy conservation efforts resulted in a significant energy savings. Compared with the FY 1973 base year, energy savings increased at shore facilities from 4.6 million barrels of oil equivalent (BOE) in FY 1975 to 5 million BOE in FY 1976.

A considerable portion of the decreased consumption of other energy sources was caused by changing to electricity as an energy source. Therefore, a significant portion of the NAVFAC energy conservation strategy addresses the development and utilization of more efficient energy utilization and generation systems. Exploratory development efforts include more efficient and alternative types of HVAC systems, building and facility monitoring and control systems, more efficient electrical systems, bottoming cycles for use with generator prime movers, improved construction methods and materials, etc.

Close coordination is being maintained with DOD and other federal agencies and industry to capitalize, to the greatest degree possible, on related efforts and technological advancements. Therefore, some of the following exploratory development tasks are directed at adapting existing technologies to suit Navy applications, and will lead into full-scale testing under the engineering development program.

Construction Methods and Materials

Objective

Construction design for energy conservation is dependent on the properties of the materials used in the construction of the building envelope structure. The required information, including thermal properties, structural characteristics, fire economics, and moisture resistance, is generally available for building materials that have been used in the past. Such information is not now available for many of the newer construction materials. An investigation will be conducted to determine what information on energy conservation is lacking and to recommend the steps necessary to obtain the required data. A new design concept for thermal buffer zones will be investigated to determine its applicability and cost benefits for new and retrofit Navy construction. Determination will also be made on the achieved versus theoretical values of insulation in Navy housing and commercial buildings.

Technical Approach

New construction materials will be surveyed to determine their energy conserving properties and fire safety information. Steps required will be based on known characteristics of the specific materials. The thermal and moisture characteristics of roofing and insulation designs will be determined; new roof and wall configurations, including thermal buffer zone concepts, will be investigated. Sufficient testing of existing insulation values will be made to obtain a significant statistical base for extrapolation to all Navy buildings.

FY 1976/77 Progress

A contract was awarded to Johns-Manville R&D Center in December 1976 for building and testing construction anomaly wall panels. A total of 10 panels were tested. The contract effort was completed at the end of FY 1977.

A preliminary draft of a materials properties catalog was submitted by Sysdyne, Inc. A review of the draft indicated that further development of the catalog is worthwhile and should be initiated.

Planned Milestones (Completion Dates)

September 1979—Perform literature search to determine thermal properties and O&M characteristics of construction materials and shell component equipment. Encourage manufacturers to determine and make available not-yet-published thermal properties and O&M characteristics of materials and construction methods that are of significance in Navy energy conservation.

September 1979—Determine thermal and moisture characteristics in built-up insulated roof designs.

August 1980—Develop methods for eliminating thermal degradation due to moisture penetration in built-up insulated roofing designs.

February 1981—Investigate commercial, industrial, and residential energy-saving shell construction concepts. Recommend Navy applications of such systems as appropriate.

September 1981—Demonstrate improved built-up insulated roofing.

September 1982—Perform tests to determine construction anomaly thermal values.

Continuing—Using the Advanced Energy Utilization Test Bed (AEUTB), evaluate candidate shell thermal systems for Navy facilities. Collect thermal, O&M, and other data on construction materials and methods. Reduce and analyze test data. Report results annually to sponsor.

Heating and Cooling Loads Computer Simulation

Objective

CEL will assist in the joint federal activities effort in the further development of the Loads and Systems Simulation (LASS) computer model. LASS will probably provide an accurate method of evaluating building heating and cooling loads required to implement the Navy's energy program. The LASS program will also be used to extrapolate the test results obtained from the AEUTB to other areas.

Technical Approach

CEL plans to closely monitor and provide specific validation and support data to this effort. Measurements using both the Canadian Research Council's pressurization/depressurization method and the National Bureau of Standards (NBS) tracer gas decay rate method will be made for a better understanding of infiltration characteristics in typical Navy structures. This information will be used to improve the infiltration calculation of the LASS program.

FY 1976/77 Progress

This project begins in FY 1978.

Planned Milestones (Completion Dates)

June 1980–Improve the Building Loads and System Thermodynamics (BLAST) simulation of building air leakage and other shell heat loss contributors using available procedures.

September 1980–Validate selected BLAST computer program algorithms in the operation of the AEUTB. Resolve differences between measured and predicted performance.

January 1981–Simulate component modifications to the AEUTB shell as appropriate. Employing BLAST, extrapolate the AEUTB to other Navy climates.

Continuing–Support federal effort to improve and utilize BLAST, employing HVAC feedback on thermal loads, improved climate situations and reference day models for specific Navy locales, and MILCON life-cycle cost analyses.

Measurement of Building Energy Losses

Objective

The objective is to evaluate and use instrumentation to locate and measure energy losses from buildings at Navy facilities.

Technical Approach

The approach includes keeping current on aerial and ground infrared (IR) survey techniques and equipment and continuing work to obtain quantifiable heat loss information from IR survey data. This could include a temperature comparator, K-factor meter, heat flux meter, and an analytical technique that accounts for wall and roof thermal transients. Detection and measurement of infiltration losses from buildings are also included in this project. Pressurization equipment and sulfur hexafloride (SF_6) chromatograph procured in FY 1976 will be used to determine component and total infiltration in typical Navy family housing units. Attempts will be made to correlate results from pressurization and SF_6 tests so that a simplified pressurization setup using components specifically sized for housing units can be developed.

FY 1976/77 Progress

Equipment procured for infiltration measurements by SF_6 tracer gas dilution and pressurization techniques has been assembled and checked out. Contracts are being maintained with industry, ASTM, and other government agencies involved with infiltration and thermography applications. Two sets of infiltration measurements were made in two family housing units at Norfolk, Virginia, in lieu of similar tests originally scheduled at NCBC, Port Hueneme, California. A meeting at ERDA on thermography requirements for energy conservation was attended, and the ERDA draft contract report was reviewed.

In addition, installation of pressurization equipment on the AEUTB was completed, and tests were conducted using SF_6 and pressurization techniques.

Planned Milestones (Completion Dates)

September 1978–Monitor or develop as necessary procedures for quantification of IR survey data.

September 1978–Develop infiltration measurement procedures using SF_6 decay and pressurization techniques.

Concrete Sandwich Construction Materials Tests

Objective

The objective is to experimentally evaluate the insulation capabilities, structural characteristics, construction advantages, and maintenance and cost benefits of using insulated expansive concrete (sandwich construction) for walls and roofs of new construction.

Technical Approach

Structural and thermal parameters of concrete sandwich construction will be determined. Thermal parameter determinations will require the design and construction of a guarded hot box. The results of the parametric tests will be compiled into design procedures for using concrete sandwich construction.

Follow-on efforts will include the design and construction of a Prototype Sandwich Structure (PSS) in the engineering development category. The design parameters developed in this work unit, coupled with standard construction procedures, are sufficient to enable transition directly from the exploratory development to the engineering development phase, without requiring any expense in advanced development.

FY 1976/77 Progress

Test measurements continued on the 20 concrete sandwich panels. Research data indicates that the amount of expansion produced in the original curing period must be increased. Expansion and shrinkage measurements continued on expansive concrete sandwich wall panels.

Planned Milestones (Completion Dates)

September 1979—Conduct stress tests on wall and roof panels.
May 1980—Conduct thermal factor tests on wall and roof panels (by contract).
December 1980—Establish design procedures.
June 1981—Prepare and publish final report.

Low-Energy Structures

Objective

The objective is to develop and demonstrate low-energy structures (LES) concepts for new construction, which will satisfy the need for reduced energy consumption.

Technical Approach

Two design concepts will ultimately be combined to yield the optimum LES. In the first design, the structure is built around a central windowed atrium or patio similar to a large skylight that supplies light and heat (winter daytime) for the rooms. Thermal insulating louvers on the windows will be used to control the light and heat transfer. Closing these louvers to thermally seal the windows during winter nights can cut space heating needs by more than half. The second design concept is to use the earth as an insulating medium. Since yearly variations in ground temperature at depths of 8 to 10 feet are small, submerged structures with a minimum of 1-foot earth cover on top to filter out the diurnal (day/night) cycle effects could prove extremely energy efficient. Coupling both concepts would result in a 70 to 80 percent reduction in space heating needs with the remaining 20 to 30 percent heating requirement being satisfied by heat from lights, instruments, people, etc.

FY 1976/77 Progress

A continuing effort is underway at the Naval Weapons Center (NWC) to monitor the ground temperature gradient to depths of 9 feet. As of March 1977, a 2-year accumulation of data had been obtained. Analyses have been conducted to compare the effects of the two design concepts, and display models of the LES concepts have been constructed. A 4-foot by 8-foot by 4-inch thick louver has been designed and fabricated, and is now ready for testing.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

Conservation
Category 6.2
NAVFAC

Seawater Cooling Survey

Objective

The objective is to determine the best Navy site for installing a seawater cooling system from four candidate Navy sites by performing bathythermographic measurements.

Technical Approach

Based on previous studies and bathythermographic measurements, one site of four being surveyed will be selected for installing a seawater cooling system.

FY 1976/77 Progress

Previous efforts have indicated that seawater cooling for buildings at coastal Navy facilities is technically and economically feasible. Four candidate sites for a seawater cooling system have been identified. A preliminary design of a seawater heat exchanger has been completed.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

Navy Cogeneration

Objective

The technical and economic feasibility of developing Navy cogeneration facilities will be determined and applicable Navy sites will be surveyed.

Technical Approach

Based on a survey of applicable Navy sites, one base will be selected for a feasibility study. The study will include both the technical and economic aspects of developing Navy cogeneration facilities as well as preliminary cost analyses and design approaches.

FY 1976/77 Progress

This project will be started in the future.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

Conservation
Category 6.2
NAVFAC

Low-Temperature Heat Recovery Power Systems

Objective

In conjunction with ERDA, the Navy will test an organic Rankine bottoming cycle in combination with a diesel-electric unit at NAS, Bermuda.

Technical Approach

Operating characteristics of large Navy diesel-electric stations will be surveyed to estimate the applicability of bottoming, followed by a preliminary design and economic analysis of a system for a specific Navy plant at NAS, Bermuda. In addition, a determination will be made of the uses and feasibility of a small organic Rankine cycle (10 kw or less) for Navy applications.

FY 1976/77 Progress

NAS, Bermuda, was selected as the test site. The program plans have been accepted by MAT-08T3 and ERDA. Detailed site data and diesel engine data have been gathered, and performance criteria for Navy organic Rankine cycles formulated.

The work unit for the small organic Rankine cycles will be initiated in the future.

Planned Milestones (Completion Dates)

October 1977—Complete preliminary design for organic Rankine cycle system at NAS, Bermuda.
—Award and monitor contract to fabricate an organic Rankine bottoming cycle power system.
—Modify facilities and install organic Rankine bottoming cycle power system.
—Monitor and evaluate operation of installed organic Rankine cycle system.
Completion dates for the second, third, and fourth milestones are yet to be determined.

Measurement of Energy Losses in Pipelines

Objective

The objective is to evaluate and use instrumentation to locate and measure, or allow the calculation of, energy losses from steam, air, water, and gas pipelines, both exposed and buried.

Technical Approach

Detection and measurement of energy losses in pipelines will be pursued under this work unit. The primary emphasis will be on steam lines where losses are the most costly; however, air, gas, and water lines will also be considered. SF_6 leak detectors will be extensively field tested to fully exploit their capabilities and to make these capabilities known to the engineering field divisions. Attempts will be made to quantify steam leaks in underground lines after the leaks are detected by IR or SF_6 inspection. SF_6 leak detectors will be used to determine their value to assess the size of leaks. Types of underground conditions (wet or dry soil, standing water, tunnel, direct burial, etc.) will be considered for the effects of masking the location and magnitude of leaks. Attempts will be made to develop techniques and instrumentation for making point-to-point steam line measurements so that overall losses can be determined.

FY 1976/77 Progress

Information from several Navy bases having suspected problem areas have been collected, and information from other bases is being requested. Available literature on the safety aspects of SF_6 leak detectors was reviewed. No safety problems were found for this particular application because of the low SF_6 concentrations needed for leak detection. Two brands of SF_6 leak detectors are on hand and are being field tested. Arrangements were made for field tests at San Diego, California, and Atsugi, Japan, and are now being performed.

Planned Milestones (Completion Dates)

June 1978–Investigate equipment and techniques used by steam utility companies and other organizations for lead detection and measurement.

December 1978–Correlate SF_6 decay and pressurization results to develop single field measurement system.

September 1979–Conduct field tests using available lead detection instrumentation (IR, SF_6, and others).

September 1979–Investigate techniques for quantifying leaks located by detection instruments.

September 1979–Monitor and participate in building energy loss investigations conducted by other federal agencies and industry.

September 1979—Validate and improve energy loss quantification techniques using test data from all available sources.

June 1980—Publish user's report on application of instrumentation for quantifying energy losses from Navy buildings.

September 1980—Develop techniques and recommend instrumentation for determining the cause, location, and extent of energy losses from steam, hot and chilled water, gas, and compressed air lines. Verify results by tests.

Electrical Conservation Technology Base

Objective

Electrical control, distribution, and power transmission equipment is being investigated for its conservation potential and applicability for use with alternative energy sources. A lighting application criteria handbook is being developed and lighting advances investigated for impact on energy conservation.

Technical Approach

An electrical conservation technology base is being developed. This may include the sizing of electrical feeders based on life-cycle costs rather than minimum code regulations. It may also look at the utilization of electricity in unregulated form as is obtained from wind generators. It will encompass state-of-the-art developments for application to Navy facilities.

FY 1976/77 Progress

A lighting design criteria handbook for Navy applications was developed. The handbook contains optimum standard lighting designs based on standards for equivalent sphere illumination and visual comfort probability. A computer program, LUMEN II, was modified to include daylighting, economic analyses, and energy savings potential to aid in lighting design applications. Another computer program, detailing a lighting maintenance procedure, was also completed. Preparation of a user's manual for the computer programs and the lighting design applications handbook was initiated.

Planned Milestones (Completion Dates)

June 1978—Submit draft lighting applications criteria report to sponsor for review.

September 1978—Revise draft lighting theory, applications, and computer program user's manual into one document.

FY 1978-83—Investigate electrical equipment, building distribution systems, and electrical power transmission systems for electrical conservation potential and for use with alternate energy sources.

FY 1979-83—Investigate lighting advances for updating theory and applications impacting on quality illumination and energy conservation.

Detection and Measurement of Energy Losses in Electrical Distribution Systems

Objective

The objective is to evaluate instrumentation and procedures to measure energy losses in electrical distribution systems, determine if additional investigation is warranted, and prepare appropriate recommendations.

Technical Approach

Portable meters for determining line losses caused by an inadequate power factor correction of individual systems, corona detection meters for estimating losses in high-voltage substation components caused by corona dischargers, and IR inspections for locating faulty connections and overloaded components will be evaluated. Field tests and cost-effectiveness analyses will be conducted to determine if losses from any of these sources warrant additional investigation. If so, a plan outlining recommended future effort will be prepared.

FY 1976/77 Progress

This work unit will begin in FY 1979.

Planned Milestones (Completion Dates)

May 1979—Conduct field tests at selected Navy bases using IR equipment, power factor meters, and corona detection meters to determine extent of losses.

September 1979—Conduct cost-effectiveness analysis of findings based on measured losses and recommended fixes.

December 1979—Prepare technical memorandum on results and outline plans for future effort.

Analysis of Installed Energy Monitoring and Control Systems (EMCS)

Objective

Existing EMCS are being examined to identify parameters affecting future procurement and system development.

Technical Approach

Existing energy monitoring and control systems will be examined for information affecting future procurement and system development, including system costs, economic and operational benefits, relative utilization of system features, system shortcomings and desirable additions, operation and maintenance problems for the system and components, and other related parameters. These data will be used to develop site survey and project development methodology, along with guidance for performing analyses of system economic effectiveness.

FY 1976/77 Progress

EMCS were evaluated in terms of operational effectiveness and economic savings. The direct and hidden benefits were studied to determine possible applications. Expansion possibilities were also studied to establish the optimum monitoring and controlling capabilities needed for a facility such as Camp Pendleton. Results were reported in a technical memorandum.

The Honeywell Delta 2000 EMCS at Camp Pendleton was evaluated, and the data were analyzed to determine the cost savings attributable to the installation of the system. A technical memorandum on the evaluation was issued. Although the Camp Pendleton Honeywell system was installed for maintenance and manpower savings, its ability to control energy usage and eliminate some wasteful practices resulted in a payback period of about one year. The capability of expanding the system to directly address energy management, including electricity consumption and demand, is also important. Monitoring of the expansion of the Camp Pendleton system was started. Significant findings on other EMCS were summarized, and a data file of useful documents compiled.

Planned Milestones (Completion Dates)

June 1979—Perform technical evaluations of effectiveness of installed systems and report results in technical memoranda.

June 1979—Analyze load selection and resultant economic benefits for inclusion in existing economic analysis guidelines.

July 1979—Analyze incremental expansion, procurement, and maintenance experience for correlation with system technology. Report significant results to sponsor in a technical memorandum.

September 1979—Prepare technical note on recommended utilization and potential economic benefits of conventional monitoring and control system technology.

Energy Conservation Handbook

Objective

The objective is to prepare an energy conservation manual for use by base level engineers.

Technical Approach

NBS has a contract to prepare an energy conservation handbook for the Air Force. The Services have similar facilities and conservation problems. The approach is for CEL to provide technical support and review of the handbook as it is formulated to ensure that it meets the basic requirements of the Navy, as well as the other Services. A handbook for new construction was completed in September 1977 by NBS. Further refinement and quantification is anticipated to adapt this handbook for Navy preliminary design applications, the energy conservation investment program, and new military construction. Handbook modifications and updates will be accomplished by contract.

FY 1976/77 Progress

The final drafts of Volumes I and II of the AF/NBS energy conservation handbook have been completed. CEL energy program engineers reviewed the handbooks for adaptation into a Navy energy handbook. This review will be culminated in a work statement for a draft Navy energy handbook to be accomplished by contract.

Planned Milestones (Completion Dates)

September 1979—Publish final new construction Navy energy handbook (by contract).
September 1985—Complete three-year updates of conservation handbooks (by contract).

Conservation
Category 6.2
NAVFAC

Energy Optimization Handbook for Navy Base Planning

Objective

The objective is to provide a handbook to predetermine optimum mixtures of environmentally driven power systems and energy conservation systems for planning naval applications.

Technical Approach

Critical operational and economic parameters for conservation devices and power systems will be identified and formulated for quantification suitable for use in a systems optimization procedure. Technical inputs from applications engineering and all other engineering divisions with conservation and power system assignments will form the basis for formulating unit characteristics. Since the evolvement of an energy optimization procedure encompasses a large volume of technology yet to be developed, a number of specific products of limited scope are defined, ultimately leading to the final procedure. The basic optimization procedure will be available as an approximate method using parametric curves and hand calculations, and also in a computerized version for more sophisticated computation. Documentation of the optimization procedure will be in the form of an energy optimization handbook for Navy base planning and will be updated periodically.

FY 1976/77 Progress

An economic analysis computer program was identified as compatible with NAVFAC P-442, "Economic Analysis Handbook." Sensitivity analysis subroutines were added to the optimization model. A work request to initiate accomplishments of milestones was issued.

Planned Milestones (Completion Dates)

September 1979—Develop machine program for energy optimization of Navy installations.
May 1980—Complete optimization planning guide.
Continuing—Update optimization planning guide periodically.

Energy Systems Application Survey

Objective

The potential applications of energy conservation devices at Navy bases will be determined. Included will be a comparison of competing conservation alternatives and a determination of the resulting economic payback.

Technical Approach

To identify the best allocations of conservation R&D funding, a base-by-base conservation application market survey will be conducted. Each base will be handled as a distinct entity and competing conservation alternatives will be prioritized.

FY 1976/77 Progress

This project will be started in the future.

Planned Milestones (Completion Dates)

—Perform energy conservation systems application survey.
—Update survey as needed.
Milestone completion dates are yet to be determined.

Application Engineering Studies

Objective

The objective is to provide RDT&E assistance to coordinate a continuous flow of technology from national energy programs to Navy field activities and others.

Technical Approach

The RDT&E applications engineering effort represents the direct application of technology to activities at Navy bases, NAVFAC headquarters, and engineering field divisions, and is designed to ease the implementation of conservation devices and installations of new power systems throughout the Navy. It is the responsibility of the applications engineer to coordinate requests for RDT&E with the appropriate program personnel at CEL to fulfill the requirements of the request within CEL capabilities. It is the responsibility of CEL principal engineers in energy conservation and advanced power systems to maintain current technology bases in their areas of expertise. It should be recognized that many requests for RDT&E are within the technical capabilities of the applications engineer. Field representation is mandatory for the installation of a system at a Navy base that is under development by CEL.

At least one applications engineer will be dedicated full time for the duration of the program to coordinate the solution of technical problems in the field. This effort involves important CEL interfaces with NAVFAC field activities, and engineering field divisions, the Navy Energy Office, ERDA, other federal agencies, and industry.

The transfer of energy technology in bulk is disseminated in a wide variety of ways: overview brochures, the CEL Energy Newsletter, Techdata Sheets, progress reports to NAVFAC, detailed handbooks, and formal CEL Technical Memorandums, Notes, and Reports. Distribution of publications is controlled by NAVMAT Instruction 5720.7A, however, and as wide a distribution as possible is sought for Energy Program Office documentation. The transfer of technology into the energy program for Navy bases is primarily the collective responsibility of every engineer and manager in CEL with energy RDT&E assignments and constitutes a significant portion of their work load.

FY 1976/77 Progress

Ten requests for assistance relating to energy problems at Navy, DOD, and other agency facilities has been completed. A continuing effort is being expended to apply and relate RDT&E projects to the field.

Wind and solar monitoring at Centerville Beach has been completed. Data corresponding with the Eureka data was assembled and correlated. A technical memorandum on the summary of the six assistance projects for FY 1976 was completed. A draft of the

SRI study at the Puget Sound Naval Ship Yard on the relationship of output to energy input was reviewed. A state-of-the-art study was performed on solar cells for cathodic protection of remote underground pipelines.

Planned Milestones (Completion Dates)

Continuing–Perform and coordinate application engineering studies as required. Document each task as completed.

Continuing–Provide technology transfer from CEL to NAVFAC, its engineering field divisions, and field activities. Interface with federal agencies and industry.

Continuing–Review, solicit, and generate Techdata Sheets, CEL Energy Forum newsletter articles, and other technical publications.

Continuing–Perform energy applications engineering for Navy requestors including labor, equipment, and instrumentation as needed.

Conservation
Category 6.2
NAVFAC

Study of Capital Expense Premium to Be Allowed for Energy Saving Physical Plant Investments

Objective

The objective is to provide a method to compute the premium in capital investment to ensure against extreme fuel/energy price escalation. The differential investment justified to offset differential fuel cost escalation is the desired result.

Technical Approach

A study related to fuel cost escalation and the consequences of not achieving energy independence in the United States is the premium in capital expense that the government should allow for energy saving physical plant investments. Finalization of the capital premium study will follow the completion of the fuel escalation study since much of its input is based on fuel pricing. The final result of both products will relate to current Navy economic practices and recommend appropriate changes.

FY 1976/77 Progress

Two strategies have been developed that determine the premium to be allowed for energy saving construction: one primarily for the short term and the other for the intermediate to long term. A draft of the final report has been completed.

This project is unfunded in FY 1978.

Planned Milestones (Completion Dates)

—Develop new concepts based on prior work.
—Prepare documentation of new concepts.
Milestone completion dates are yet to be determined.

Conservation
Category 6.2
NAVFAC

Data Compilation for Energy Consumption and Facility Operational Statistics

Objective

The objective is to compile on-site data and statistics related to energy demand and consumption at naval installations.

Technical Approach

Fuel and electrical consumption data are available on a base-by-base tabulation from a computer program—Defense Energy Information System for Navy Utilities (DEIS-II). The program contains consumption and cost of coal, petroleum products, electricity, steam and hot water, natural gas and propane, or liquified petroleum gas, and the 1973 (baseline) consumption, by month, for each of 580 activities. This data will be analyzed and aligned as to parameters of interest, such as climate, geographical location, fuel transportation cost, and types of energy systems on base. The actual breakdown in energy demand by end-use category is not available from DEIS-II, and on-site monitoring and investigation will be required at typical Navy bases to be able to accurately estimate end-use energy consumption. The operating and maintenance cost and reliability of existing boilers, diesel engines, gas turbines, HVAC systems, and other power facilities are of importance to allow the quantitative comparison of new power system candidates with current facilities.

FY 1976/77 Progress

Technical Memorandum M-52-77-4, "Preliminary Report on the Estimation of End-Use of Navy Base Energy Consumption," has been printed. Two different methods of estimating end use of electrical energy at the Point Mugu, California, Navy complex (PMTC) compared well. The simpler method could be used to obtain a Navy-wide estimate of end use, by questionnaire, in an expeditious manner. End-use categories appropriate to the Navy-wide extension of this study have been devised.

Space heating use and cost for over 500 separately accountable Navy activities have been estimated from the FY 1976 DEIS-II. A similar estimate has been made for a fewer number of activities for air conditioning energy consumption and cost. The method used for both of these estimates is essentially the same as those used for the special survey of Navy and Marine Corps family housing.

Acquisition of the Energy Data Mobile Laboratory (EDML) will increase the number of locations at which measurements can be made due to time saved in transportation of instrumentation and set up at measurement sites, as well as minimizing handling damage.

Modifications to the EDML vehicle shell have been made for the installation of instrumentation. A 1,600-mile shakedown trip demonstrated the reliability of the vehicle.

Assistance to the PMTC, Point Mugu, California, Public Works Department Energy Officer was provided. Installation of 160 additional watt-hour meters, 36 of which have pulse generation features permitting continuous recording of electrical consumption and calculation of usage rates, has been completed. Transmission will be over available telephone lines through the use of encoders and decoders and data loggers, feeding into a computer-compatible tape recording device.

All planned instrumentation has been checked. Field measurements using the EDML have begun.

Planned Milestones (Completion Dates)

Continuing–Acquire and store fuel and electrical power consumption and cost data. Report annually.

Continuing–Collate energy demand data and analyze for causal relationships. Report annually.

Continuing–Inventory shore activity power systems and compile data on performance, maintenance, and reliability. Report annually.

Continuing–Measure the end use of energy (light, heat, cooling, losses, industrial, and other) at bases representing a spread of climatic types for periods necessary for establishing long-term patterns.

September 1978–Provide special assistance, advice and information to the NAVFAC/NESO BTU, air-conditioning tune-up and other data-base-related activities.

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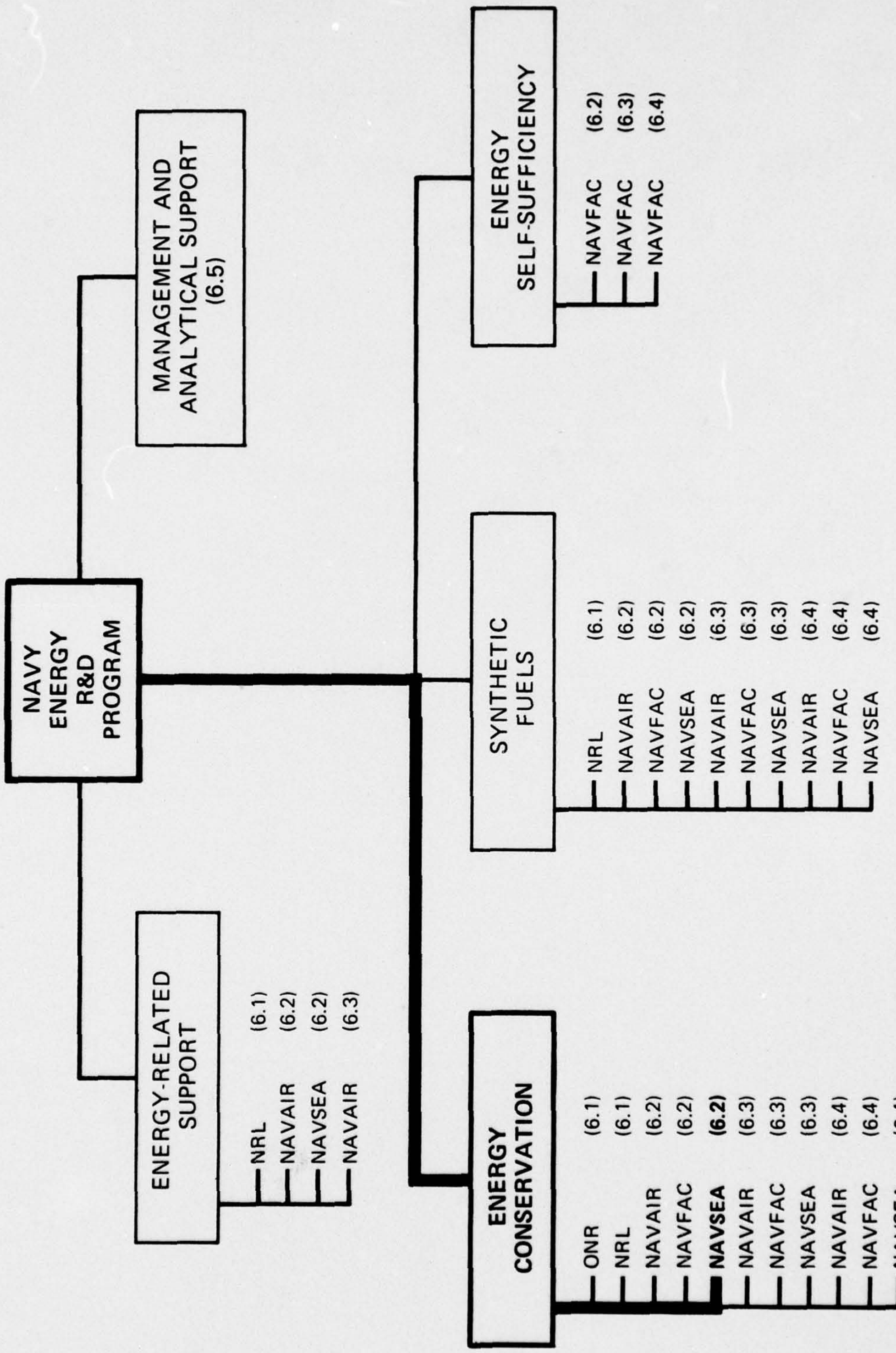
ENERGY CONSERVATION
EXPLORATORY DEVELOPMENT (6.2)
NAVSEA


NAVY ENERGY R&D PROGRAM
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY-RELATED SUPPORT
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NAVAIR (6.2)
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ENERGY SELF-SUFFICIENCY
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NAVFAC (6.4)

2.3.3 Naval Sea Systems Command (NAVSEA)
New Energy Sources
P.E. 62765N
Task Area SF 57-571-005

Introduction

The NAVSEA exploratory development program is essentially an ongoing effort to review and analyze the state-of-the-art in energy technology as it may be applied to shipboard systems. This program includes investigation of the two broad energy technology areas: energy conservation aboard ship and new fuel sources. The energy conservation aboard ship effort emphasizes the development of more efficient shipboard machinery systems. The new fuel sources effort is oriented towards the development of nonpetroleum fossil fuel sources. The primary emphasis of this effort is the conversion of oil shale, tar sands, and coal into liquid fuels for shipboard use that would meet military fuels specification. The direction of the energy conservation aboard ship effort is significantly different from that of the new fuel sources effort. (These two efforts are not actually distinct tasks funded separately within the energy conservation aboard ship and new fuel sources work unit.) A flexibil[illegible]mphasis between the two broad technical areas must be maintained to allow for [illegible]ration of new developments and changes in emphasis in the national energy program. However, for categorization purposes, the energy conservation aboard ship effort is described separately in this energy conservation category. Similarly, the new fuel sources effort is described in the synthetic fuels category.

Figure B-2 shows the overall NAVSEA exploratory development program in energy conservation. This figure shows the program logic, the interrelationships between work units, and the progression of data and products through the development sequence. It also shows how the exploratory development program is related to the follow-on advanced development and engineering development programs.

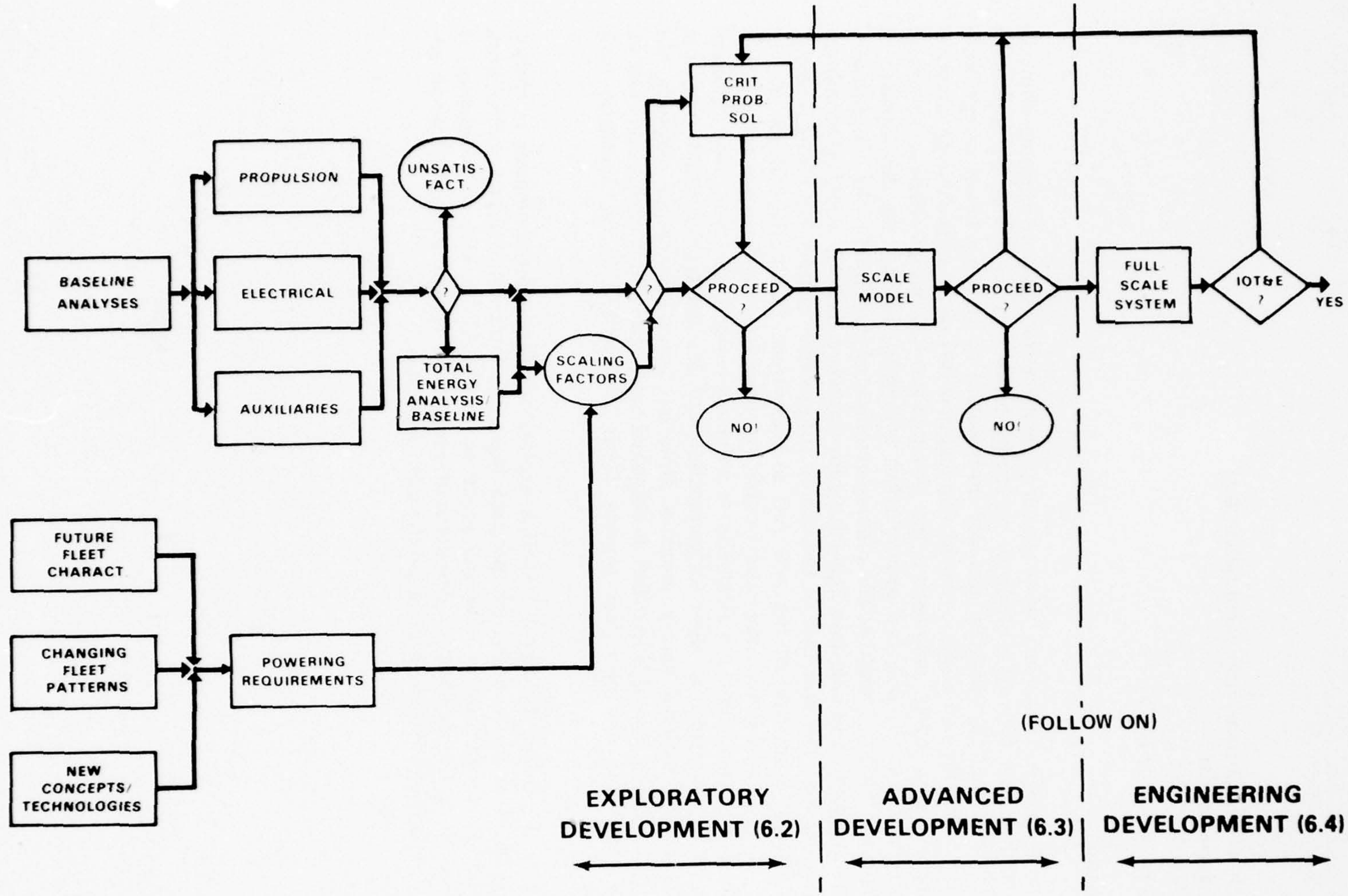


Figure B-2. NAVSEA ENERGY CONSERVATION PROGRAMS

Energy Conservation Aboard Ship

Objective

Energy conservation technology for shipboard systems emphasizes the development of more efficient shipboard machinery systems. This exploratory development phase seeks to determine the potential for reduced fuel consumption in future ships and craft through the implementation of alternative propulsion and auxiliary subsystems and to solve the technological problems that represent impediments to hardware demonstrations in the 6.3 Category and 6.4 Category programs. The goal is to realize a 15 percent to 70 percent improvement in the efficiency of individual systems and at least a 20 percent efficiency improvement overall.

Technical Approach

The technical approach consists of several parallel efforts:

- The future nonnuclear fleet is to be characterized in terms of projected ship types, powering requirements, requisite mission capabilities, and anticipated date of fleet implementation. Projections of fleet characterization are based upon the Surface Warfare Plan, POM submissions, the Extended Planning Annex, and extrapolations to the year 2000. Powering requirements for proposed ships and craft are calculated based upon the projected mission requirements and the anticipated displacements and hull forms.
- Propulsion and auxiliary systems alternatives are to be synthesized to identify energy-related design parameters. These proposed systems are to be evaluated in terms of their ability to effect minimum energy consumption and life-cycle cost, while satisfying operational requirements.
- Developmental problems and risks are to be identified for systems that offer the potential of minimum fuel consumption after analysis on a total-ship basis.
- Where the necessary technology base is not sufficient, exploratory development programs are to be directed toward demonstrating the feasibility of pursuing hardware demonstrations. Upon realization of the potential of competing concepts, either project termination (where no advantage can be demonstrated) or graduation into advanced development is to be recommended.
- Where total-ship systems analyses result in positive recommendations for implementation of systems currently in the developmental cycle, the existing program is to be expedited to the extent necessary to ensure a reasonable probability of component availability relative to a projected ship construction schedule.
- Basic research and related interagency efforts are to be continuously monitored to identify new concepts that offer energy conservation potential. Continuing exploratory development programs are to be structured on this basis.

- In terms of changing fleet patterns, propulsion and auxiliary systems analyses are to be reassessed on a continuing basis to accommodate new machinery system requirements not foreseen in previous studies.

DTNSRDC, Annapolis, is block funded to manage the overall energy conservation aboard ship and new fuel sources effort. A considerable portion of the analytical work involved will be distributed to various other Navy organizations and qualified contractors. Organizations other than DTNSRDC participating in this program include:

- Naval Ship Engineering Center, Hyattsville, Md.
- Naval Ship Engineering Center, Philadelphia Division
- Hydronautics, Inc.
- J.J. Henry Co.
- Stanford Research Institute
- Battelle Memorial Institute, Columbus Laboratories
- PFR, Inc.
- Booz-Allen & Hamilton, Inc.
- Tetra Tech, Inc.

FY 1976/77 Progress

The energy conservation aboard ship effort, which is directed at the future non-nuclear fleet, was initiated in FY 1975 with the analysis of machinery systems options for baseline gas turbine-powered destroyer and hydrofoil platforms representative of the future fleet vehicles. These analyses form the basis for projections of the energy conservation potential of the various options for future vehicles and for components and systems development under the associated advanced and engineering development efforts. When necessary, laboratory investigations are conducted to supplement existing data.

To establish baseline characteristics that could be used to extrapolate the requirements of future ships and craft, energy-related design parameters and energy consumption characteristics of the major subsystems of destroyer and hydrofoil baselines were determined during FY 1975. Based upon 1975 data, a total of 90 propulsion system and 48 ship's service electrical system alternatives were synthesized during FY 1976. These two subsystems were initially considered because the remaining shipboard auxiliary subsystems are dependent upon the characteristics of these major subsystems. First, these were screened according to their fuel consumption characteristics over typical mission profiles. Detailed analyses, including performance, life-cycle cost, effectiveness, and developmental risk assessment, were conducted for those concepts that exhibited superior fuel consumption characteristics. Based on NAVSEA recommendation, a computer program to conduct life-cycle cost analyses and of a realistic procurement schedule which considered logistics cost impact was developed.

In FY 1976, the major energy users (exclusive of propulsion and electrical generation) were identified for the two baseline platforms. A program plan to analyze the energy intensiveness of major auxiliary system options was formulated. A study of destroyer lighting systems was completed in FY 197T and several hardware areas were recommended for shipboard suitability studies and cost analysis. Analyses of the

destroyer platform hydronic pumping systems were initiated in FY 197T and preliminary investigations of HVAC systems were initiated preparatory to formulating a work statement to be issued as an RFP for detailed studies.

A contract was awarded in FY 1977 to procure a Shipboard Total Energy Model (STEM). This model would allow integrated energy studies of all shipboard systems to identify optimum energy conservative arrangements on a total ship basis.

As an outgrowth of the survey and assessment studies, several specific tasks were initiated in FY 1976-77. An analysis of the response of free-turbine engines for ship's service power applications was conducted. A compilation of an energy data bank for shipboard machinery systems documentation was initiated. A study of shipboard diesel noise and failure data was initiated.

During FY 1977, a computer model was completed and is being used to conduct detailed cost studies of those electrical and propulsion options that are energy conservative. Concepts meeting criteria for payback period and cumulative life-cycle savings have been recommended for further development. The study to identify shipboard diesel failures and their causes was completed and the results are being integrated with other ongoing propulsion and electrical studies. Recommendations for development of advanced propulsion and ship's service systems were made and procurement actions and ship impact studies were initiated as 6.3 or 6.4 tasks as appropriate. A contract was let to study a new type of propulsion-derived ship's service power using liquid cooled generators and associated components.

Shipboard suitability studies of lighting systems were completed, as were the associated cost analyses. Candidate lighting systems were recommended for further development.

The destroyer hydronic pumping system analyses were completed and cost analyses of various energy conservative options were conducted. Considerable emphasis was placed upon resolution of technological problems concerned with alternative shipboard components and systems preliminary to initiation by FY 1978 of hardware demonstrations under the advanced and engineering development programs.

An RFP was prepared and issued to investigate HVAC systems. Design criteria will be reviewed, alternative HVAC configurations will be synthesized and analyzed, and cost and effectiveness data will be collected.

The STEM contract was initiated, the resulting program installed on DTNSRDC's CDC 6700 computer, and a series of validating test cases exercised. A library of component data was developed to serve as baseline reference data for the STEM. A study of energy storage systems potentially compatible with shipboard requirements was conducted and the results integrated into the STEM component library.

The future fleet was characterized in terms of ship type and powering requirements so as to provide mechanisms for scaling the baseline results to projected future ship types and provide for prioritization of developmental efforts.

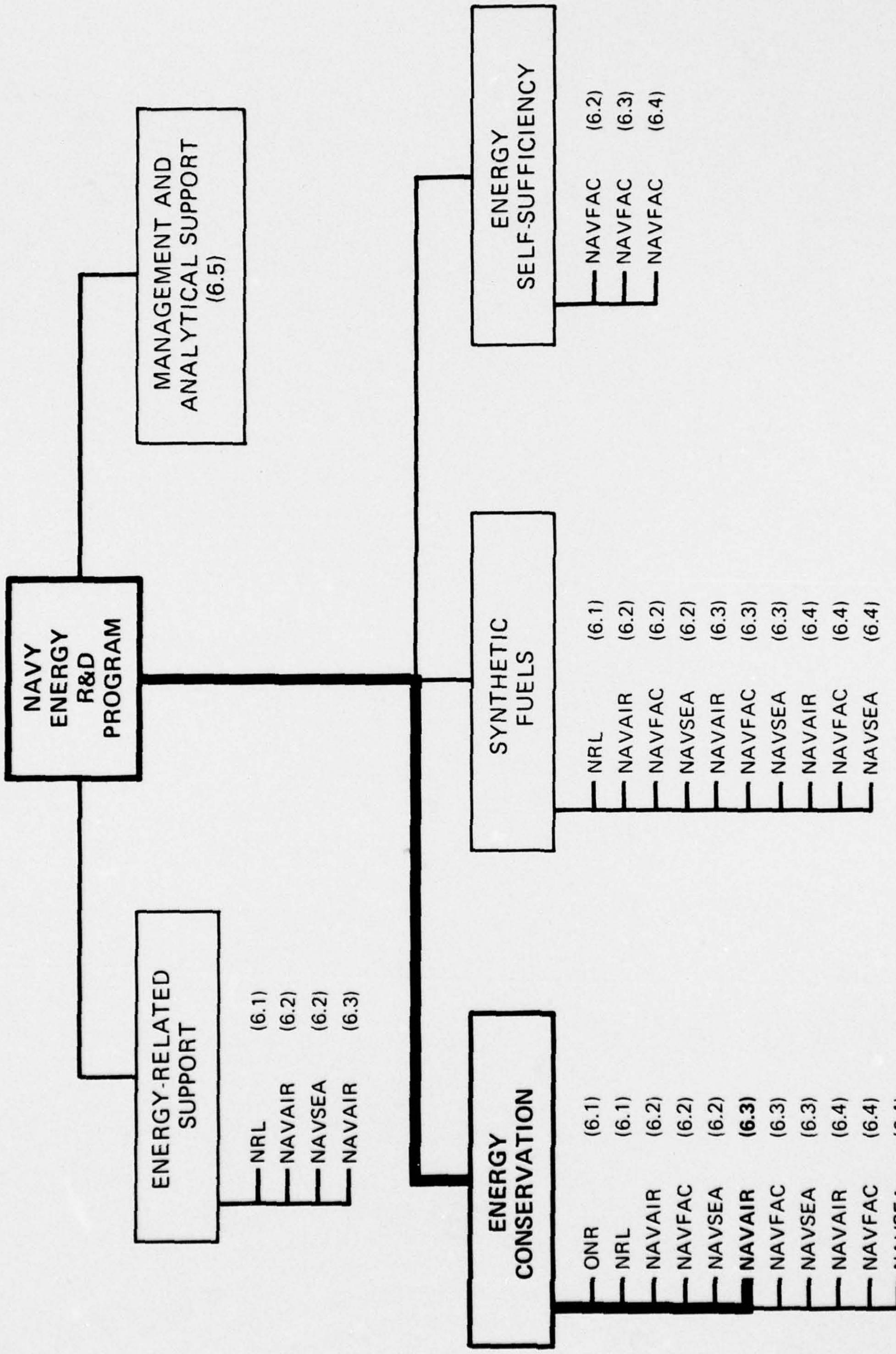
Planned Milestones (Completion Dates)

FY 1978–Establish the feasibility of using the main propulsion system to provide ship's service power for the baseline platform and extrapolated to other ship classes. Lighting system components will be procured, tested shipboard incompatibilities will be resolved, and the transition into advanced and engineering development will be pursued, as appropriate. Technological problems associated with advanced efficient pump elements and drives will be addressed, and a program for their resolution will be initiated. Commonality between the many shipboard pump systems will be emphasized. The baseline HVAC systems analysis will be completed and cost and effectiveness data collected and analyzed. Ship suitability studies will be completed on energy-efficient systems and the critical technical problems will be addressed. Specific energy storage systems will be evaluated in conjunction with baseline total energy analyses. An integrated total ship design methodology whose goal is the optimally energy efficient ship based on mission requirements will be developed.

1979-82–Reassess continually the R&D priorities in terms of the:

- Changing nature of the fleet.
- Developmental programs evolving from basic research efforts.
- Concepts developed for unrelated applications that appear to have merit for naval systems.
- Demonstration of suitability for further development leading to fleet implementation of attractive concepts.
- Satisfactory solution of a critical developmental problem.

ENERGY CONSERVATION
ADVANCED DEVELOPMENT (6.3)
NAVAIR


NAVY ENERGY R&D PROGRAM
ENERGY-RELATED SUPPORT
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NAVAIR (6.3)
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY CONSERVATION
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ENERGY SELF-SUFFICIENCY
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2.4 ADVANCED DEVELOPMENT (6.3)

2.4.1 NAVAIR

Aircraft Energy Conservation
P.E. 63210N
Project W05XX

Introduction

NAVAIR 6.2 exploratory development work in FY 1978 is expected to result in advanced development tasks in FY 1979. NAVAIR currently has one Category 6.3 project with direct energy conservation benefits, even though the primary objective is directed at engine applications. This project is included in this section for information, even though it is not funded as part of the Navy Energy R&D Program.

Long Endurance Aircraft Engine

Objective

The objective is to initiate the development of a high-efficiency engine for application to Navy long-endurance patrol aircraft.

Technical Approach

The engine will be built around an existing engine core. Fan and shaft engines will be considered. During FY 1977, the propulsion/airframe analysis program will determine the cycle requirements for the engine. During FY 1978-80, the development of the engine will be continued and completed.

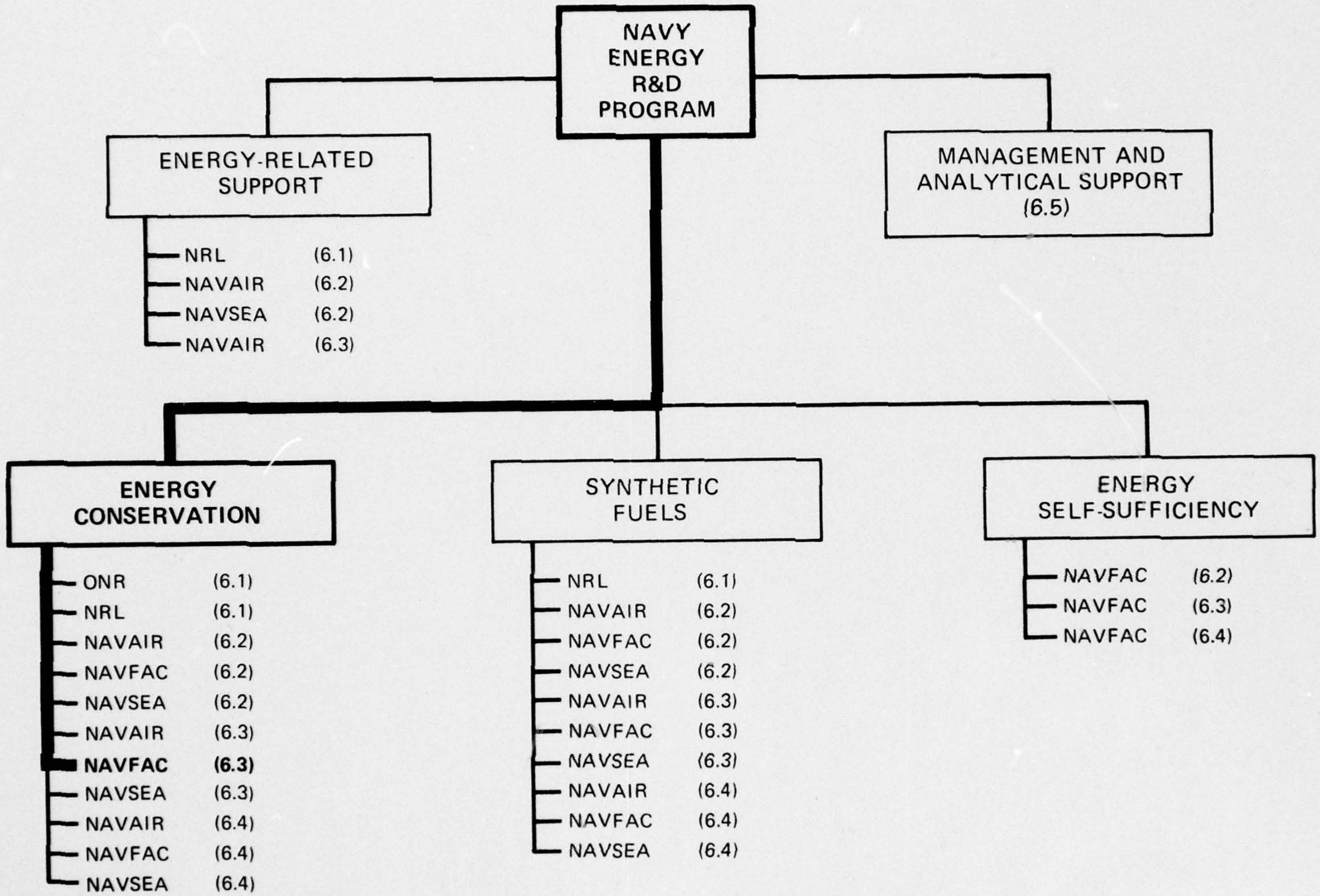
FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones

–Initiate propulsion/airframe analysis program.
–Complete propulsion/airframe analysis program.
–Initiate engine development.
–Complete engine fabrication and initial operational checkout (two engines).
–Complete engine advanced development, sea-level and altitude test programs, and associated subsystem development.

ENERGY CONSERVATION
ADVANCED DEVELOPMENT (6.3)
NAVFAC


NAVY ENERGY R&D PROGRAM
ENERGY-RELATED SUPPORT
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NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY CONSERVATION
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NAVSEA (6.4)
ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
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NAVFAC (6.4)

2.4.2 NAVFAC
Shore Facilities Energy Conservation
P.E. 63724N
Project Z0829

Introduction

Many NAVFAC efforts in exploratory development are directed toward adapting existing technologies to naval facilities applications. In some instances, the technological adaptation accomplished may be sufficient to allow the work unit to proceed directly to full-scale testing/demonstration under engineering development. However, in other instances, uncertainties in the present state-of-the-art are such that project definition has not been attempted beyond advanced development.

Navy Cogeneration

Objective

A technical and economic analysis will be made of equipment and design concepts for developing Navy cogeneration facilities.

Technical Approach

An in-depth analysis for cogeneration plants will be performed on all applicable Navy sites resulting from the exploratory development efforts. A public works cogeneration planning guide will be developed.

FY 1976/77 Progress

This project will be started in the future.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

Electrical Systems Experiments

Objective

NAVFAC will verify and apply theory developed from electrical conservation technology base project. Automatic lighting control systems for quality illumination and electrical conservation will be developed and tested, and a lighting maintenance scheduling computer program will be developed.

Technical Approach

Electrical systems experiments will verify and apply theory developed from the electrical conservation technology base. This may include the development and evaluation of devices and equipment that can operate effectively on unregulated electrical energy. It will include appropriate modifications and switching networks for building electrical distribution systems so that effective utilization of commercial and alternate sources of electricity can be achieved.

One often overlooked area for energy conservation is maintenance. Systems are often overdesigned to compensate for poor maintenance. Poor maintenance also leads to higher system operating losses. Attention to maintenance can reduce both overdesign and operating losses. Minimizing the losses in the transmission, distribution, and consumption of electricity leads to significantly better regulation, which in turn leads to a higher operating efficiency. Increased efficiency and reduced overdesign results in tangible electrical conservation. Because of the leverage that often exists between energy costs and labor costs, increased maintenance can lead to a reduction in electricity, an increase in jobs, and an overall reduction in costs, while maintaining the same level of operational benefits.

FY 1976/77 Progress

Lighting systems were surveyed and promising concepts selected. One commercially developed (General Electric) and two CEL-developed light-sensing and control systems were evaluated. The General Electric system appears to be a cost-effective retrofit to existing lighting systems, such as those in hallway and storage areas. CEL's two-level light-sensing and control system can also be a cost-effective retrofit. CEL's constant-illumination-level controlling system was found to be an ideal lighting control system for conserving energy, but would be cost effective only on new construction.

Tests were conducted on low wattage and phantom fluorescent lamps to determine their cost-effectiveness, and the results reported.

Laboratory experiments on dimming and high-frequency lighting systems were started. A standard luminaire was connected to a variable frequency AC-AC converter. Good dimming was achieved at 105 to 300 Hz with a standard ballast.

Development of a solid-state dimming ballast was completed. A microprocessor in such a ballast could be programmed to deliver optimum visibility and energy conservation based on photocell control.

A contract was awarded to develop a visual comfort probability (VCP) meter. An *equivalent sphere illumination* (ESI) meter was procured. Coupled with the microprocessor-based illumination system, the ESI and VCP meters will allow evaluation of lighting systems. For a given room location and task, a correlation between raw footcandles and ESI and VCP can be computed.

Planned Milestones (Completion Dates)

March 1978—Develop routine illumination maintenance scheduling computer program.
FY 1978-83—Develop microprocessor-based lighting control systems.
FY 1978-83—Perform laboratory and functional experiments and tests on lighting equipment for quality illumination and electrical conservation.
FY 1978-83—Perform laboratory and functional experiments on electrical equipment and power systems to determine and verify capabilities for electrical conservation and use with alternative energy sources.

Conservation
Category 6.3
NAVFAC

Engineering Guidance for Energy Monitoring and Control Systems (EMCS)

Objective

The objective is to determine the operational capabilities for representative EMCS with particular emphasis on a high technology computing system, and the impact on energy monitoring and control.

Technical Approach

Detailed operational capabilities will be sought for representative systems, with particular emphasis on high technology computing systems and their impact on energy monitoring and control. The cost-effectiveness of a building-block approach to energy control will be investigated, wherein microprocessor technology is used in small, inexpensive building blocks to fit facility size and complexity, with a minimum of cost and interfacing complexity to add additional features. New system capabilities, combined with knowledge gained from existing systems, will provide engineering guidance for future Navy applications.

FY 1976/77 Progress

Literature on available EMCS was obtained from manufacturers, and a reference file established. Personal contacts were established with users or potential users in the Navy and other organizations.

Design specifications for available EMCS were obtained from the three major vendors who produce 80 percent of the systems. State-of-the-art technology has not been incorporated into these systems. Less prominent manufacturers or high-technology groups are, however, using state-of-the-art technology to produce EMCS, and are achieving better results at one-tenth the cost of the three major vendors.

CEL began work to:

- Determine facility load patterns using Defense Energy Information System for Navy Utilities (DEIS-II) data tapes.
- Evaluate methods of determining the cost-effectiveness of EMCS.
- Obtain energy costs and usage of facilities before EMCS installation to determine system efficiencies.

Planned Milestones (Completion Dates)

FY 1978-83—Investigate application of high-technology computer systems to large- and small-scale monitoring and control.

FY 1978-83–Investigate potential impact and relative merits of new sensors, controls, and control philosophies.

FY 1978-83–Formulate engineering guidance for selecting and utilizing monitoring and control systems and report results annually in technical memoranda.

November 1977–Develop microprocessor time clock with analysis features.

May 1978–Demonstrate incremental expansion of time clock to higher order control capability.

September 1978–Perform economic analysis of time clock expansion concept and report recommendations in a technical memorandum.

FY 1978-83–Develop control system hardware and software for use of new sensors, controls, and control philosophies.

FY 1978-83–Determine economic and operational potential of new sensors, controls, and control philosophies.

Energy Conservation Handbook

Objective

The objective is to compile on-site data and statistics related to energy demand and consumption at Navy installations for the formulation of a conservation handbook for retrofit applications.

Technical Approach

NBS has a contract to prepare an energy conservation handbook for the Air Force. The Services have similar facilities and conservation problems. The approach is for CEL to provide technical support and review of the handbook as it is formulated to ensure that it meets the basic requirements of the Navy, as well as the other Services. A handbook for retrofitting existing facilities was completed by NBS in September 1976. Further refinement and quantification is anticipated to adapt this handbook for Navy preliminary design applications, the energy conservation investment program, and new military construction. Handbook modifications and updates will be accomplished by contract.

FY 1976/77 Progress

This project is unfunded in FY 1978.

Planned Milestones (Completion Dates)

–Award contract for modifications of AF/NBS retrofit energy conservation handbook.
–Publish Navy interim retrofit energy conservation handbook (by contract).
Milestone completion dates are yet to be determined.

Recommendations on Efficiency Improvement Devices for Conventional Boilers

Objective

Efficiency improvement devices, procedures, and concepts will be developed and evaluated.

Technical Approach

New boiler hardware, procedures, and concepts for efficiency improvement will be developed. This will include the test and evaluation of devices such as turbulators, emulsion fired burners, low nitrogen oxide burners, special operating techniques to modify the combustion process boiler controls, and fuel additives. Safety and emission control will not be sacrificed. Operational boilers will be used for these evaluations to verify performance, modification procedures, and effects on maintenance requirements. The results will be formally documented in a technical memorandum at the conclusion of each experiment. Recommendations will be made on the suitability for Navy adaptations.

FY 1976/77 Progress

This project will begin in FY 1979.

Planned Milestones (Completion Dates)

September 1980—Develop potential efficiency improvement techniques and devices.
June 1981—Perform tests of the most promising techniques and devices.
September 1981—Prepare a technical memorandum on test results and recommendations.

Instrumentation Packages for Field Surveys

Objective

The objective is to determine suitable instrumentation and formulate a user's guide for conducting field surveys of energy losses.

Technical Approach

Available instrumentation will be surveyed and attractive units will be procured for controlled testing. Tests are to be conducted on portable IR imaging systems, heat flux meters, and associated systems. Three sets of instrumentation will be selected, procured, and checked out for field use by field survey teams. Selection of instruments to be included in the final package will be based on the test results. A user's guide will be formulated based on manufacturer's instructions and data gathered during the tests. Procurement and final testing will be accomplished under engineering development.

FY 1976/77 Progress

Major items for the packages have been procured. Comparative cold weather field tests with the AGA 750 and the Inframetrics 510 IR sets indicated the lower priced 510 model is satisfactory for energy loss surveys. This will permit the procurement of three packages instead of the planned two. Geoscience Ltd. development and test work on transient R-value measurement and methodology was upgraded to contract report level and submitted for printing.

Planned Milestones (Completion Dates)

February 1978—Assist NAVFAC personnel in energy survey techniques using recommended instrumentation packages.

Navy Industrial Use Surveys

Objective

Industrial facility energy losses will be determined by performing energy loss surveys at Navy shipyards and aircraft rework facilities.

Technical Approach

A methodology will be developed for both the scope and the techniques to be used in the industrial surveys at government-owned, contractor-operated facilities, shipyards, and Naval Air Rework Facilities.

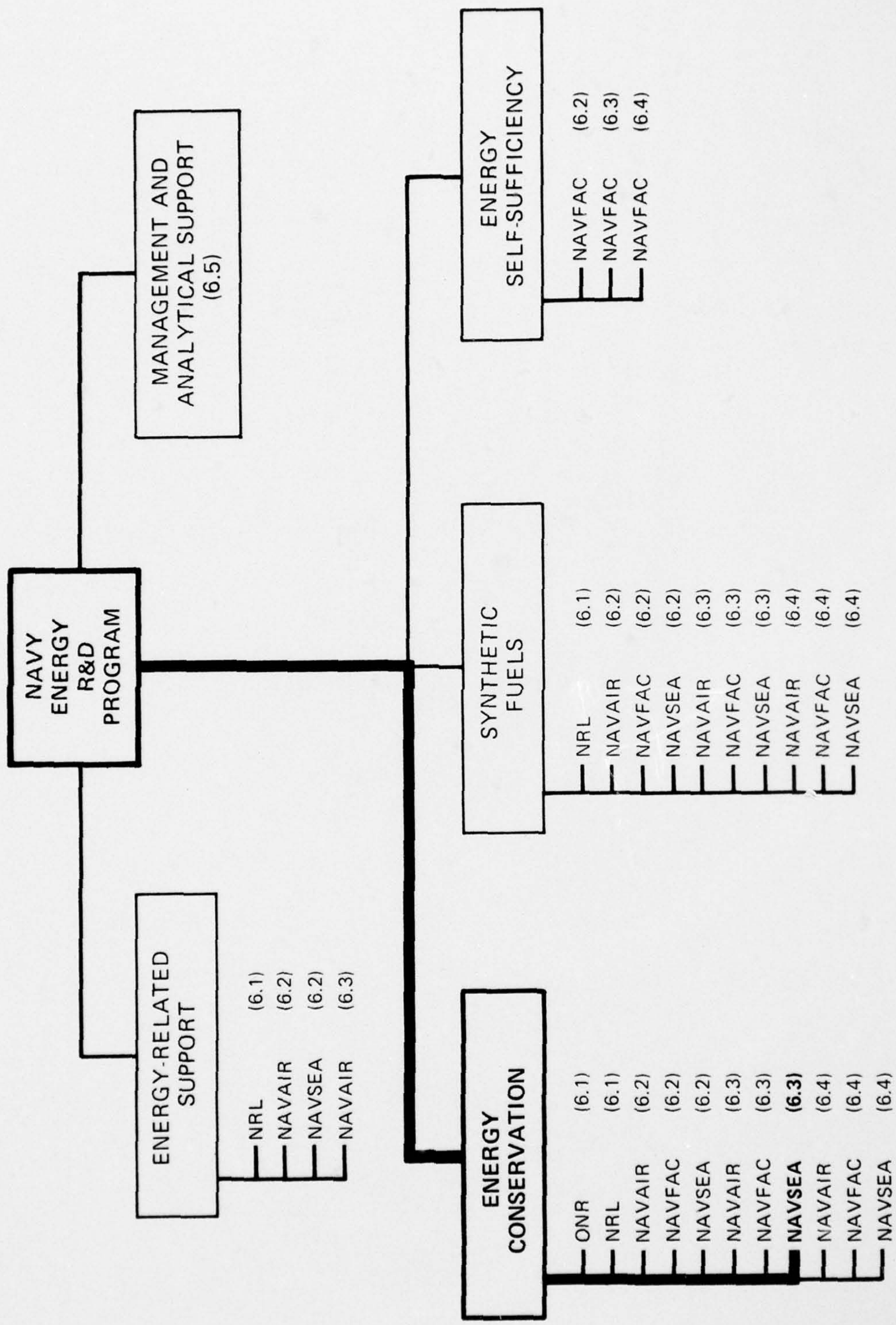
FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

Milestones are yet to be determined.

ENERGY CONSERVATION
ADVANCED DEVELOPMENT (6.3)
NAVSEA



NAVY ENERGY R&D PROGRAM
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2.4.3 NAVSEA
Shipboard Energy Conservation
P.E. 63724N
Project Z0829 (SEA)

Introduction

A new advanced development initiative was approved in FY 1977 and is included in the POM-78 package to fill the gap now existing in the evolving process leading to future-fleet implementation of improved components and systems. The intent of this initiative is to support the advancement of those technologies that either evolve from or are recommended in the exploratory development energy R&D programs. This new advanced development initiative will consist of two new tasks, hull maintenance and advanced ship components. Advanced ship components efforts will be initiated in FY 1978 to provide full-scale test and qualification of advanced machinery components and subsystems for the future fleet. Hull maintenance projects include improved hull cleaning methods and improved hull coatings efforts, which have been under way in engineering development.

The hull maintenance task in this advanced development work unit began in FY 1977 and includes development of improved underwater hull cleaning techniques; biofouling protection systems; improved hull, sonar dome, and propeller coatings; and associated laboratory analyses. Shipboard testing will be conducted under the shipboard energy conservation work unit in engineering development. The advanced development hull maintenance task actually consists of three subtasks: hull cleaning, biofouling protection systems, and hull coatings. Since these three subtasks have distinct objectives and milestones, they will be described separately.

Figures B-3 and B-4 illustrate the program logic of each task; these tasks will provide the groundwork for the engineering development counterparts.

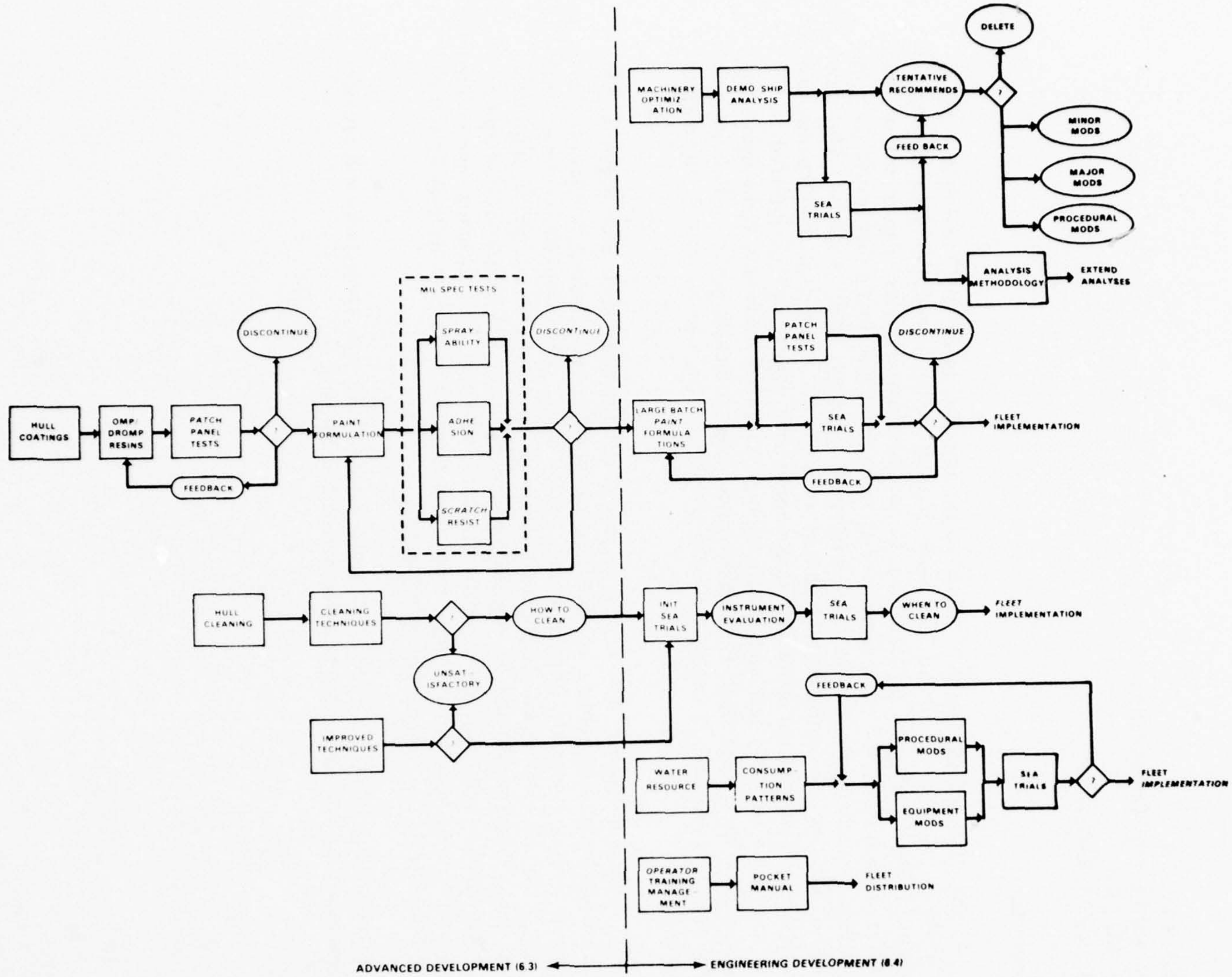

Figure B-3. ADVANCED DEVELOPMENT HULL COATINGS AND HULL CLEANING–ENERGY CONSERVATION

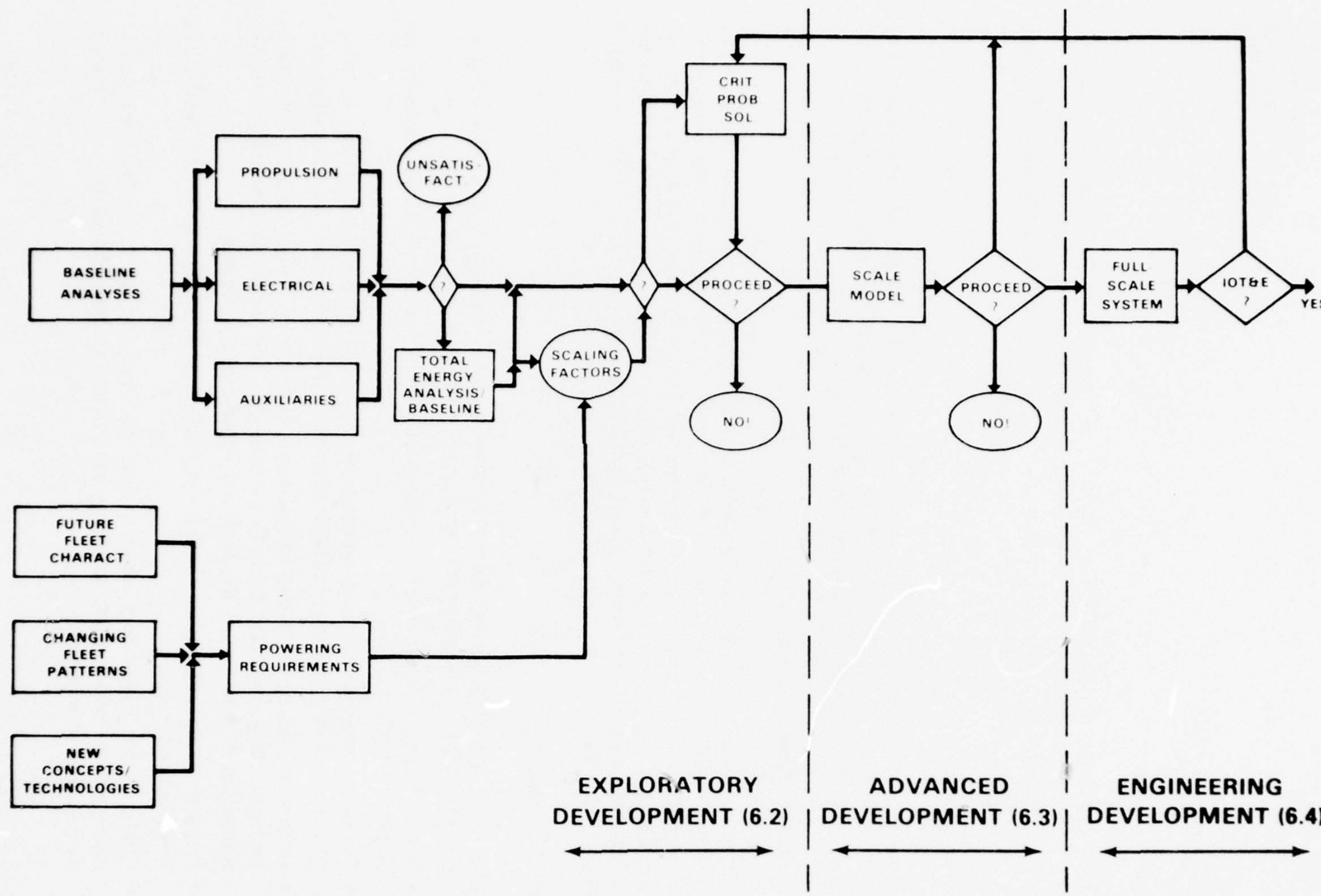

Figure B-4. ADVANCED DEVELOPMENT ADVANCED SHIP COMPONENTS–ENERGY CONSERVATION

Hull Maintenance

Objective

The objective of this and the related 6.4 program is to initially reduce and ultimately eliminate the fuel consumption penalties associated with the accretion of biofouling on ship hulls, propellers, and sonar domes. This fouling constitutes the single largest inefficiency associated with underway operations.

Technical Approach

The technical approach of this project is to develop improved underwater hull cleaning techniques; biofouling protection systems; improved hull, sonar dome, and propeller coatings; and associated laboratory analyses.

Biofouling Protection Systems

Ultrasonic devices of different frequencies, intensities, and configurations are being tested to determine their effectiveness for protecting sea chest materials and components against fouling. A biofouling protection system will ensure that shipboard propulsion and machinery systems efficiencies are not compromised by reduced heat exchanger effectiveness or cooling water flow. Commercially available systems as well as NSCL developed hardware will be used.

Hull Cleaning

The basic approach of the overall program used to determine how and when to conduct in situ cleaning of hull, sonar dome, and propeller surfaces is to:

- Survey current hull cleaning technologies and select candidate methods for shipboard trials.
- Evaluate candidate cleaning methods on the basis of availability, cleaning effectiveness, and compatibility with paint systems by laboratory and field investigation.
- Determine the cost-effective time interval between successive cleaning operations by conducting shipboard trials to measure the fuel penalty/fouling relationship as a function of time out of drydock and time since last cleaning.
- Prepare recommendations based on the results from laboratory and field investigations.
- Continue the laboratory development of improved cleaning techniques with emphasis on reducing the relatively labor intensiveness characteristic of present diver-deployed methods.

Hull Coatings

The laboratory development, test, and evaluation of organometallic polymer (OMP) paints, previously conducted under project 64710N, Z0371, is now under this project. OMP paints formulated for use on ship hulls will be laboratory tested for compliance with current military specifications and environmental safety as well as the ability to keep ship hulls fouling free for 5 to 7 years without cleaning. Special application coatings designed for use on propellers, sonar domes, and intakes will be developed by (1) chemically altering commercially available and laboratory synthesized polyurethane and epoxy resins to incorporate OMP antifoulants, and (2) laboratory testing the performance of the coatings, under conditions designed to simulate actual propeller, sonar dome, and intake operations. Both the OMP paints for ship hulls and special application coatings will be tested for compliance with current military paint specifications and evaluated through patch-panel inversion tests. Enough paint of the most promising polymers will be procured to conduct shipboard evaluations under project 64710N, Z0371.

FY 1976/77 Progress

Biofouling Protection Systems

Progress in hardware development for this project included the fabrication of the driver units for all tests. Transducers were completed for Series 1 (laboratory tests) with frequencies of 100, 200, 300, 400, 600, 700, and 800 kilohertz. Piezoelectric ceramics with a resonance of 500 kilohertz will be included in the Series 2 tests (shipboard tests) due to late delivery.

Progress in testing for this project included measurements of beam patterns and acoustic intensity for Series 1 transducers irradiating through steel plates prior to their installation for field tests. The catamaran raft which provides a platform for field tests was launched in May.

Series 1 of the frequency effectiveness tests was begun. Swept frequency transducers were completed for electrical inputs of 70, 40, 20, and 10 watts. Tests at higher inputs clearly demonstrated the effectiveness of ultrasound for fouling protection. These findings are reported in more detail in project reports.

Hull Cleaning

Candidate underwater hull cleaning techniques were evaluated from a hardware and operational viewpoint. Both diver-operated hand-held rotary brushes as well as semiautomatic hull cleaning devices were investigated.

A state-of-the-art survey was conducted of underwater applied paints to assess their applicability for repairing hull paint damage between regular overhauls.

A program was initiated to evaluate techniques including jets for cleaning recessed areas and sea chests. A program was also initiated to determine the "scrubbability" and refouling rate of aged antifouling paints.

Hull Coatings

In work on hull coatings:

- 150 OMP resins were synthesized.
- Four resins remained fouling-free for 5 years.
- Five contracts for coating formulation were awarded.
- Over 40 coatings were received.
- Volatility, leach rate, and acute toxicology studies on OMPs 1, 2, and 5 were completed.
- BUMED approval was received on first group of coatings.
- An environmental impact assessment was prepared.
- Military specification tests on coatings were conducted.
- Static immersion tests were started.
- Special application coating development was started.
- BUMED approved the remainder of the coatings.
- BUMED authorized and NAVSEA applied belly stripes to light ships.
- Large-batch polymers were procured.
- OMP 4 was reformulated.

Planned Milestones (Completion Dates)

Biofouling Protection Systems

October 1976–Begin preliminary tests.
October 1976–Procure ultrasonic systems.
January 1977–Complete design of NCSL test systems.
April 1977–Complete assembly of initial NCSL system.
May 1977–Complete preliminary tests of commercial systems.
June 1977–Begin antifouling tests of NCSL system.
September 1977–Report results of preliminary tests.
November 1977–Finalize design of prototype system.
January 1978–Build prototype.
July 1978–Complete system tests.
August 1978–Report results.

Hull Cleaning

September 1977–Complete development of rotary brush to effectively remove intermediate fouling without damaging paint.
December 1977–Complete evaluation of propeller cleaning brush.
September 1978–Complete analysis of propeller cleaning impact (surface roughness and feasibility of jets).
September 1979–Complete development of recess and sea chart cleaning methods.

September 1979–Complete investigation of refouling and wear of aged paint systems.
September 1977–Complete optimization of hard-held scrubbers.
June 1977–Complete evaluation of existing commercial brushes.
June 1977–Complete state-of-the-art survey of underwater applied paints.

Hull Coatings

OMP Coatings

November 1976–Conduct degradation studies.
May 1977–Receive coatings and test panels.
August 1977–Conduct toxicology studies.
September 1977–Reformulate OMP 4.
January 1978–Formulate coatings based on reformulated OMP 4.
January 1978–Continue investigation of plasma-sprayed coatings.
April 1978–Reformulate selected OMP hull coatings.
May 1980–Conduct antifouling tests.

Special Applications

September 1977–Complete polyurethane synthesis.
June 1978–Investigate suitability of OMP polyurethanes.
September 1978–Evaluate OMP rubber materials.
September 1978–Complete simulated sonar dome tests.
September 1978–Incorporate toxicant into plasma sprayed coatings.
September 1980–Complete simulated propeller tests.

Advanced Ship Components

Objective

This work unit will provide for model tests and hardware demonstrations of machinery systems and components that have the potential to reduce fuel consumption through improved efficiency, but not reducing the effectiveness and mission capability, of future nonnuclear ships and craft. It provides for the experimental demonstration of the feasibility of combining the technologies developed during the exploratory development phase into technological building blocks. The goal is to provide proof of the advantage to be gained through the application of a new technology, as well as to define additional development necessary before proceeding to the engineering development program.

Technical Approach

The methodology to be pursued in determining the nature and extent of support provided under this work unit is somewhat flexible. In summary the methodology is:

- When an advanced development program is recommended that does not involve an effort currently in the developmental cycle or an effort that does not come within the purview of another NAVSEA program office, the Energy R&D Office will propose to lead the development. This is the most direct form of participation and those subsystems or systems qualifying for this type of advanced development support would continue through the developmental cycle, leading to fleet implementation in the same context. Efforts during this phase could be conducted entirely within Navy laboratories, but in most cases would require contractor participation.
- When a developmental program is identified that is not already in the development cycle but does come within the scope of an existing NAVSEA program office, the Energy R&D Office will lead the effort by providing funding and design criteria. This will be done through the appropriate organization.
- When an effort already in the developmental cycle as an existing NAVSEA program could benefit from additional support, the Energy R&D Office will participate by providing supplemental funding and continuing analyses of energy-related design parameters. This will be done through the already established program.
- When the technology assessment conducted during the course of the exploratory development phase indicates that there is a significant energy-saving potential associated with a developmental program that is well established and fully funded under an unrelated program element, the Energy R&D Office will encourage progress with no direct participation. In this context, the Energy R&D Office will make available to the responsible program manager estimates of the energy

conservation potential of the development and will provide continuing analyses to assess the merit of the development for alternate applications. However, the Energy R&D Office will not take an active role in the program.

- When technology appears to have possible merit for naval application but is being developed by another agency for an unrelated application, the Energy R&D Office may elect to monitor the program. This would represent the minimum degree of participation; the Navy would merely indicate a possible future interest in the subsystem or system development.

The specific tasks currently under way or planned for initiation in FY 1978 as part of this project are propulsion-derived ship service power, reverse osmosis desalination, improved hull design, diesel noise analysis, heat-powered air conditioning, and advanced pumping systems.

FY 1976/77 Progress

Propulsion-Derived Ship Service Power

High efficiency inverters with efficiencies of up to 95 percent were investigated for flexibility. Analyses of the ability of propulsion prime movers to provide sufficient electrical power at low speeds were conducted. Studies of trade-offs between liquid-cooled alternators and homopolar generators were initiated.

Reverse Osmosis Desalination

The component development program was started and included work on improved ultrafiltration, improved membrane technology and high efficiency, compact, high-pressure brine pumps in support of reverse osmosis developments. The objective is to produce 6000 gpd units with 16,000 hours mean time between failure (MTBF).

Improved Hull Design

Efforts were initiated including hull form improvements, improved stern design, novel appendage design, novel propulsors, and improved propulsive efficiency in a seaway.

Diesel Noise Analysis

This effort concentrated on determination of projected ASW noise requirements for future combatants and an analysis of existing or projected silencing techniques to quiet 10,000 to 15,000 hp diesel engines when utilized as propulsion prime movers. With regard to arrangement design, the ability of current and projected gas turbine combatants to utilize diesel engines as cruise (base) engines is being investigated with particular consideration to center of gravity versus metacentric height, and the ability to perform in-place maintenance. These efforts are directed at an attempt to determine the feasibility of exploiting the considerable efficiency advantages offered by diesel engines at certain ship speeds.

Heat-Powered Air Conditioning

This work element begins in FY 1978.

Advanced Pumping Systems

An analysis of alternative pumping systems was completed. Contributions of various pumps were determined. Shipboard fire main and seawater service pumps had the highest power requirements. Alternatives include different pump types, and operating procedures. They are being pursued primarily for these systems but also with spinoffs for all others where appropriate.

Planned Milestones (Completion Dates)

Propulsion-Derived Ship Service Power

March 1979–Complete inverter development.
June 1979–Complete system design.
December 1979–Complete prototype fabrication.
December 1980–Complete test and evaluation.

Reverse Osmosis Desalination

March 1978–Improve ultrafiltration.
September 1978–Improve membranes.
September 1979–Complete high-pressure brine pumps.
December 1979–Complete system design feasibility (6000 gpd system at 80 Btu per pound for current systems).

Improved Hull Design

December 1977–Complete white papers.
September 1978–Complete design analysis.
December 1978–Complete novel appendage model tests.
September 1979–Complete novel propulsion development.
December 1979–Make design recommendations.

Diesel Noise Analysis

December 1977–Complete noise analysis.
March 1978–Complete design study.
June 1978–Make follow-on recommendations.

Heat-Powered Air Conditioning

For the purpose of continuity, both 6.2 and 6.3 milestones are given for this work element. The 6.2 milestones occurred in FY 1977, and the 6.3 milestones will occur in FY 1978.

April 1977–Complete alternate system identification.
August 1977–Award design study/cost-effectiveness contract.
December 1977–Complete design study contract.
January 1978–Recommend specific hardware development.
March 1978–Initiate hardware development.

Advanced Pumping Systems

For the purpose of continuity, both 6.2 and 6.3 milestones are given for this work element. The 6.2 milestones occurred in FY 1977, and the 6.3 milestones will occur in FY 1978.

April 1977–Complete energy analysis
June 1977–Complete advanced component/system identification.
December 1977–Complete specific hardware suitability studies.
March 1977–Initiate component/system development.

ENERGY CONSERVATION
ENGINEERING DEVELOPMENT (6.4)
NAVAIR

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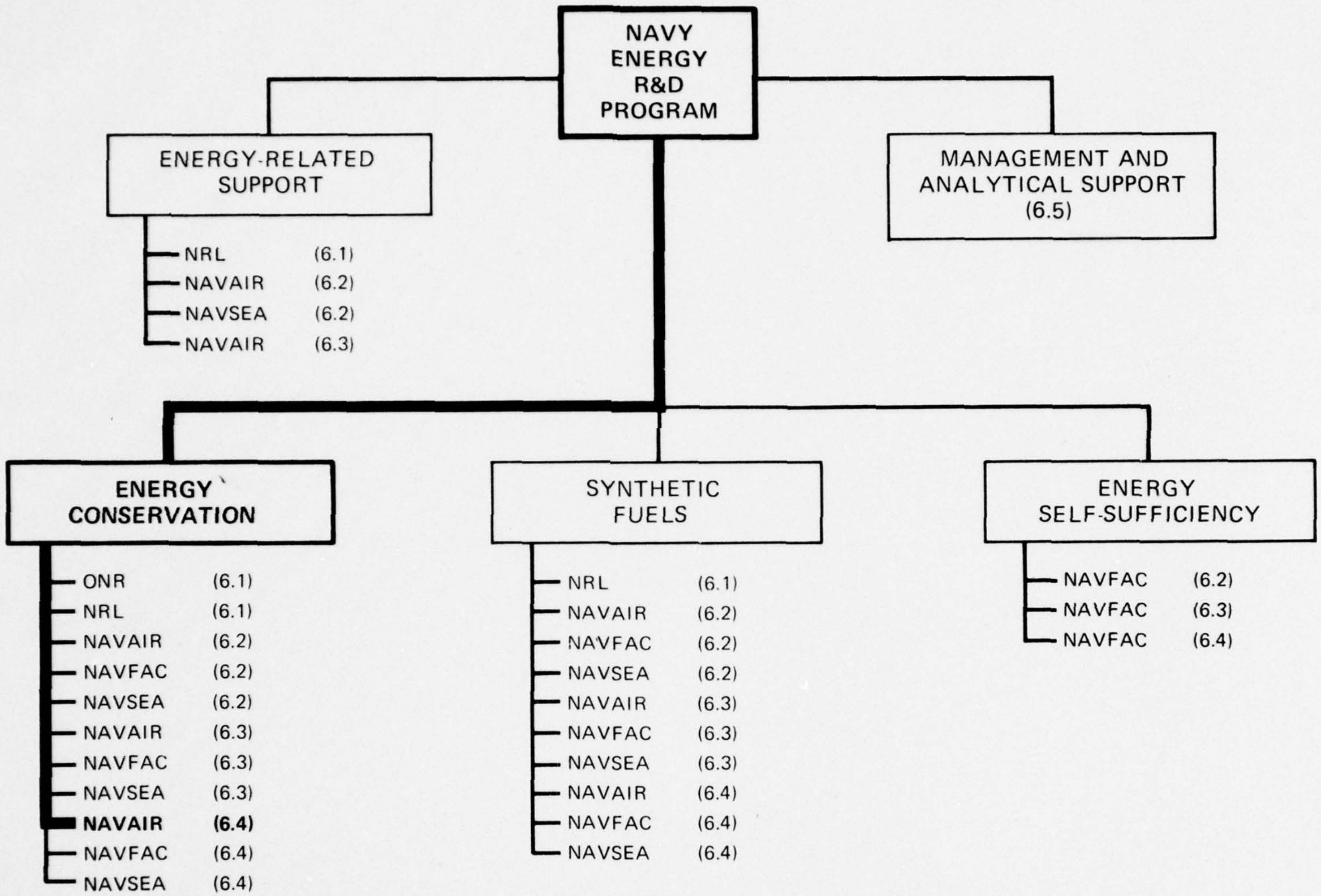

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2.5 ENGINEERING DEVELOPMENT (6.4)

2.5.1 NAVAIR
Aircraft Energy Conservation

Introduction

NAVAIR has no aircraft engineering development energy conservation work.

ENERGY CONSERVATION
ENGINEERING DEVELOPMENT (6.4)
NAVFAC

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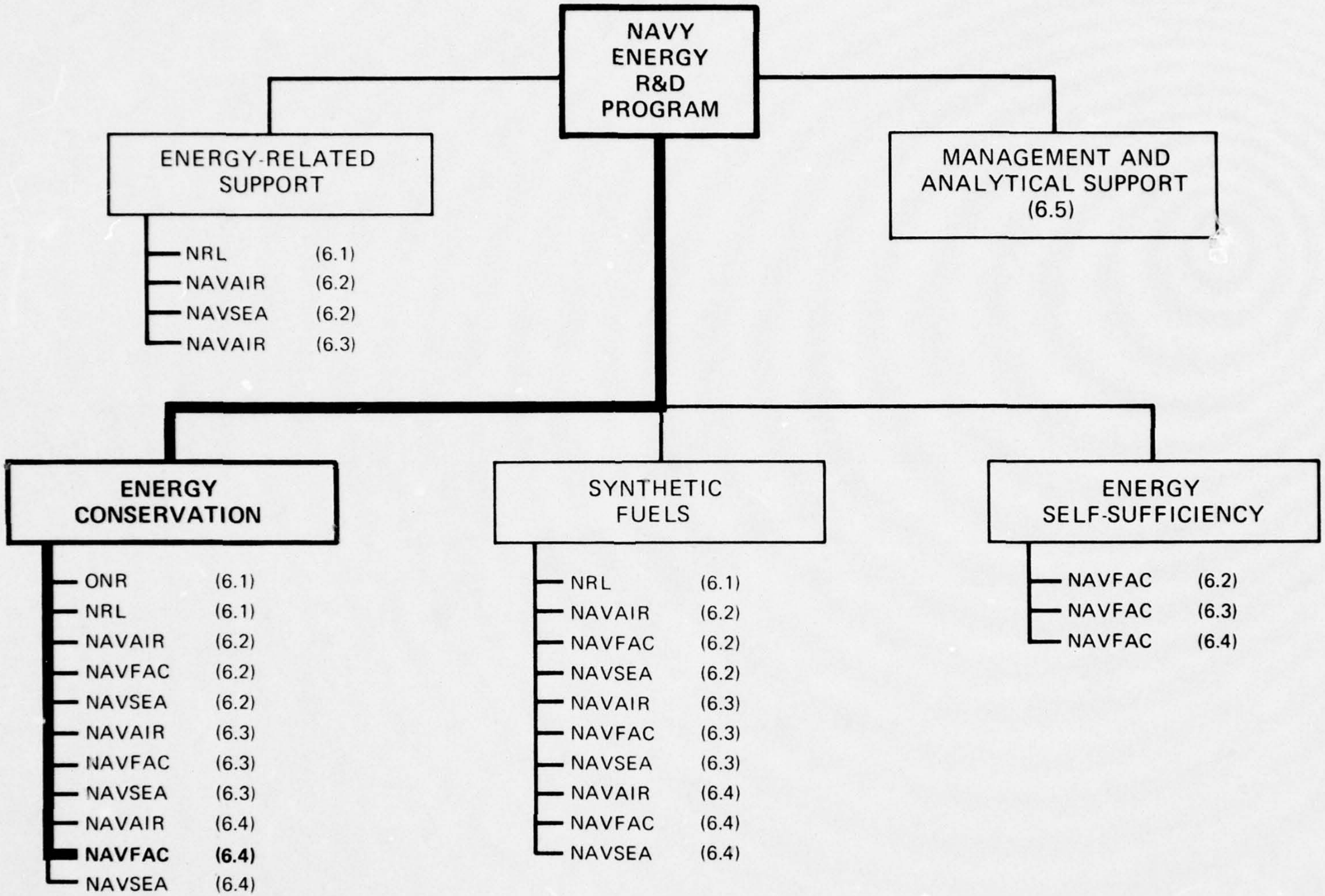

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2.5.2 NAVFAC
Shore Facilities Energy Conservation
P.E. 64710N
Project Number Z0371

Introduction

Some of the NAVFAC engineering development work units will proceed directly from exploratory development to engineering development with no intermediate advanced development efforts required. These are primarily adaptations of existing technologies to meet Navy requirements.

In other instances, engineering development follow-on to planned advanced development work units has not yet been defined because of present uncertainties in the state-of-the-art. The number of engineering development programs can be expected to grow as these uncertainties are resolved and program objectives are defined.

Conservation
Category 6.4
NAVFAC

Polyurethane Foam Roofing Systems

Objective

The objective is to determine optimum polyurethane roofing systems and maintenance procedures for new applications on Navy facilities.

Technical Approach

Investigations will be conducted to determine the optimum polyurethane roofing systems for new applications on Navy facilities. Improved maintenance procedures will also be considered.

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

January 1978–Conduct fire tests on polyurethane foam applied to steel decks.
September 1979–Conduct cooperative field studies with LANTDNNAVFAC. Report annually by technical memorandum.
September 1979–Determine effects of aging on thermal efficiency of insulation.
December 1979–Prepare final report.

Seawater Cooling of Buildings

Objective

A seawater air conditioning system will be designed, fabricated, installed, and tested at a Navy operating site.

Technical Approach

Final design of a seawater cooling system will be prepared by contract and analyzed by CEL. A model seawater cooling plant will be built and tested; test results will be analyzed to determine the potential for energy conservation. A specific demonstration site for testing the model will be selected.

FY 1976/77 Progress

Previous work (done as part of the exploratory development program) indicated that using seawater for cooling buildings and condensing moisture from humid air at Navy coastal facilities is technically and economically feasible.

A contract was awarded in December to Tracor Marine, Port Everglades, Florida, for the preliminary design. The preliminary design was completed in March and is being studied by CEL.

This project is unfunded in FY 1978.

Planned Milestones (Completion Dates)

–Prepare final design, fabrication, instrumentation, and installation of the demonstration seawater cooling system at NSGA, Winter Harbor, Maine, on a not-to-interfere-with-operations basis.
–Collect data on the operating system.

Milestone completion dates are yet to be determined.

Navy Cogeneration

Objective

The objective is to develop, construct, and demonstrate a cogeneration plant.

Technical Approach

A prototype cogeneration plant will be developed and demonstrated at a selected Navy site.

FY 1976/77 Progress

This project will be started in the future.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

Conservation
Category 6.4
NAVFAC

Economic and Operational Potential for High Technology Modifications of Installed Energy Monitoring and Control Systems (EMCS)

Objective

The objective is to apply microprocessor technology for modifying installed EMCS and evaluate economic and operational feasibility.

Technical Approach

A high technology system will be procured to develop a cost profile for retrofitting an existing EMCS that is not meeting operational needs. Analysis tools will be included so that the operational and economic effectiveness of the retrofit can be determined to provide a data base for improving other Navy systems.

FY 1976/77 Progress

Available sites for application of a microprocessor-based modification have been investigated.

Planned Milestones (Completion Dates)

December 1977—Investigate available sites for application of high technology modifications.
March 1978—Perform study of energy use profile at chosen facility.
March 1978—Develop high technology modification to existing system incorporating state-of-the-art control features and analysis capability.
June 1980—Perform analysis of control system enhancement with high technology modifications, and report interim recommendations in a technical memorandum.
September 1980—Prepare final report (technical note).

Conservation
Category 6.4
NAVFAC

Recommendations on Efficiency Improvements for Conventional Boilers

Objective

The objective is to demonstrate new concepts for improving the efficiency of conventional Navy boilers.

Technical Approach

New boiler hardware, procedures, and concepts for efficiency improvements will be demonstrated.

FY 1976/77 Progress

This project will be started in the future.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

Conservation
Category 6.4
NAVFAC

Air Conditioning Tune-up Program

Objective

The objective is to demonstrate a test program to detect, locate, and correct problems in Navy air conditioning systems.

Technical Approach

One large Navy facility will be selected to study the types of air conditioning used and the amount of energy required. Corrective measures will be implemented along with an analysis of the savings impact. The results of this test program will be used to produce procedural documentation that will be applied Navywide.

FY 1976/77 Progress

This project will be started in FY 1978.

Planned Milestones (Completion Dates)

February 1978–Define program.
September 1978–Complete tests.

Low Energy Structures

Objective

The objective is to develop and demonstrate low energy structures concepts for retrofit construction on existing buildings which will satisfy the need for reduced energy consumption.

Technical Approach

Based on exploratory development work, existing buildings will be characterized by function, construction type, consumption, and retrofit suitability. Retrofit components and concepts will be demonstrated.

FY 1976/77 Progress

This project will be started in FY 1978.

Planned Milestones (Completion Dates)

May 1978—Categorize existing Navy buildings.
September 1978—Demonstrate low energy structure concepts for louvers and atriums.
September 1980—Demonstrate component retrofit.

Industrial Surveys

Objective

Energy end-use of an aircraft/avionics government-owned contractor-operated facility will be determined.

Technical Approach

Based on advanced development work, a pilot survey will be conducted at a Navy shipyard and a Naval Air Rework Facility.

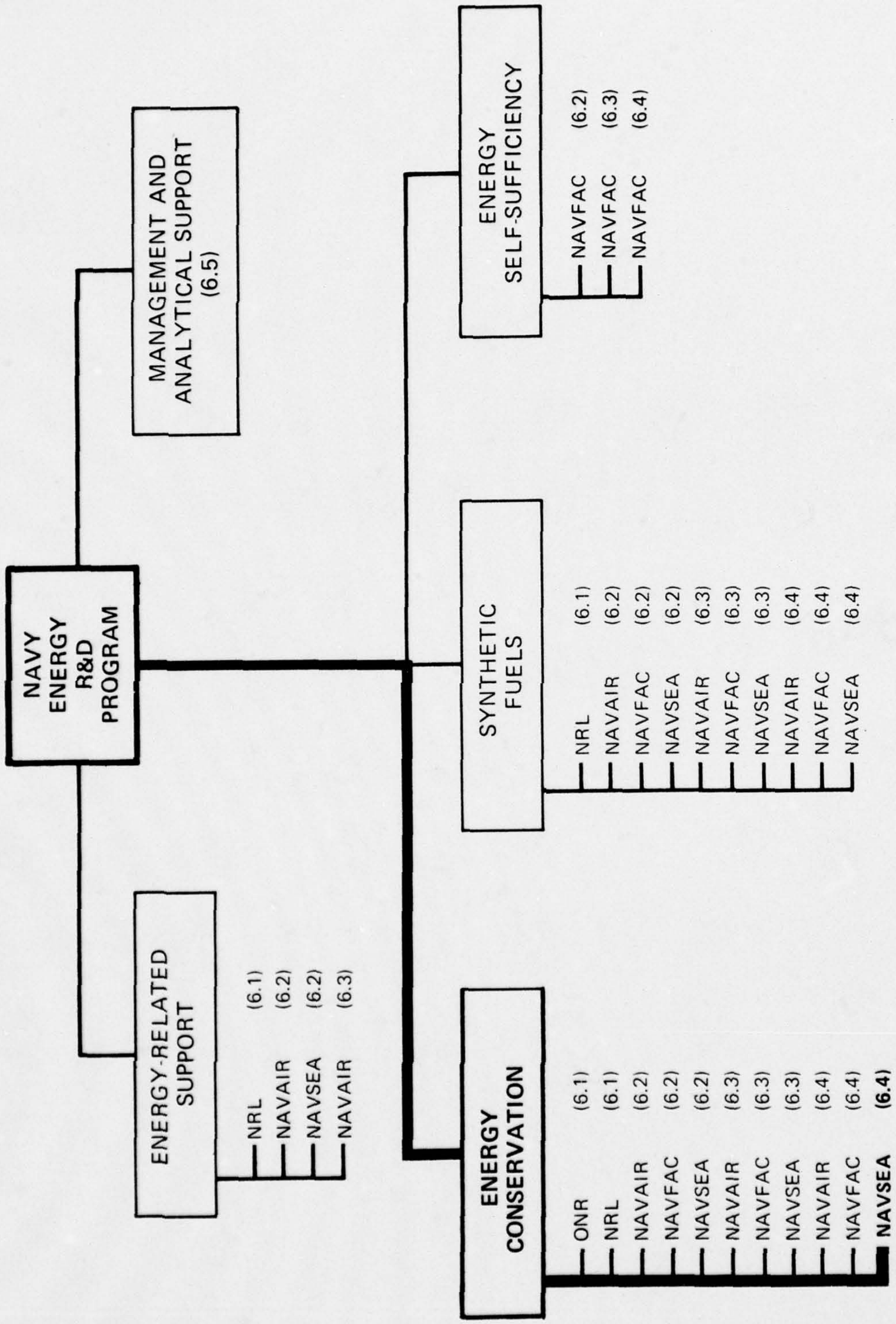
FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

ENERGY CONSERVATION
ENGINEERING DEVELOPMENT (6.4)
NAVSEA


NAVY ENERGY R&D PROGRAM
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
ENERGY CONSERVATION
ONR (6.1)
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NAVSEA (6.4)
ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
NAVFAC (6.3)
NAVFAC (6.4)

2.5.3 NAVSEA
Shipboard Energy Conservation
P.E. 64710N
Project Number Z0371

Introduction

The NAVSEA engineering development program in energy conservation is directed toward the engineering development of improved, energy-efficient systems and practices for shipboard operation. Improved efficiency propulsion and auxiliary systems for existing and future ships are to be developed, and the testing of improved hull maintenance and drag reducing technologies are to be accomplished through sea trials test and evaluation and through full-scale land-based testing.

The shipboard energy conservation project began in FY 1975 and is directed to:

- Identify energy-intensive machinery systems and operating procedures and implement procedural and equipment modifications to reduce their energy intensiveness.
- Encourage responsible personnel action in the operation and maintenance of shipboard equipment.
- Develop hull maintenance technology to reduce frictional drag.
- Implement water resource management techniques.

These objectives are presently addressed in a number of separate ongoing subtasks:

- Hull maintenance (drag reduction)
- Machinery optimization
- Stack gas analyzer
- 2,000 kw quiet diesel generator
- Shipboard machinery performance monitoring
- Water resource management.

Because each of these tasks have discernible objectives and milestones, they are described by subtask. The overall objective of the shipboard energy conservation project is to achieve a 20 percent reduction in shipboard energy usage. Improved hull maintenance is expected to reduce present and future fleet energy consumption by 10 percent, and future fleet systems energy requirements will be reduced by as much as 40 percent, relative to specific present systems. Figure B-5 shows existing/future fleet energy conservation.

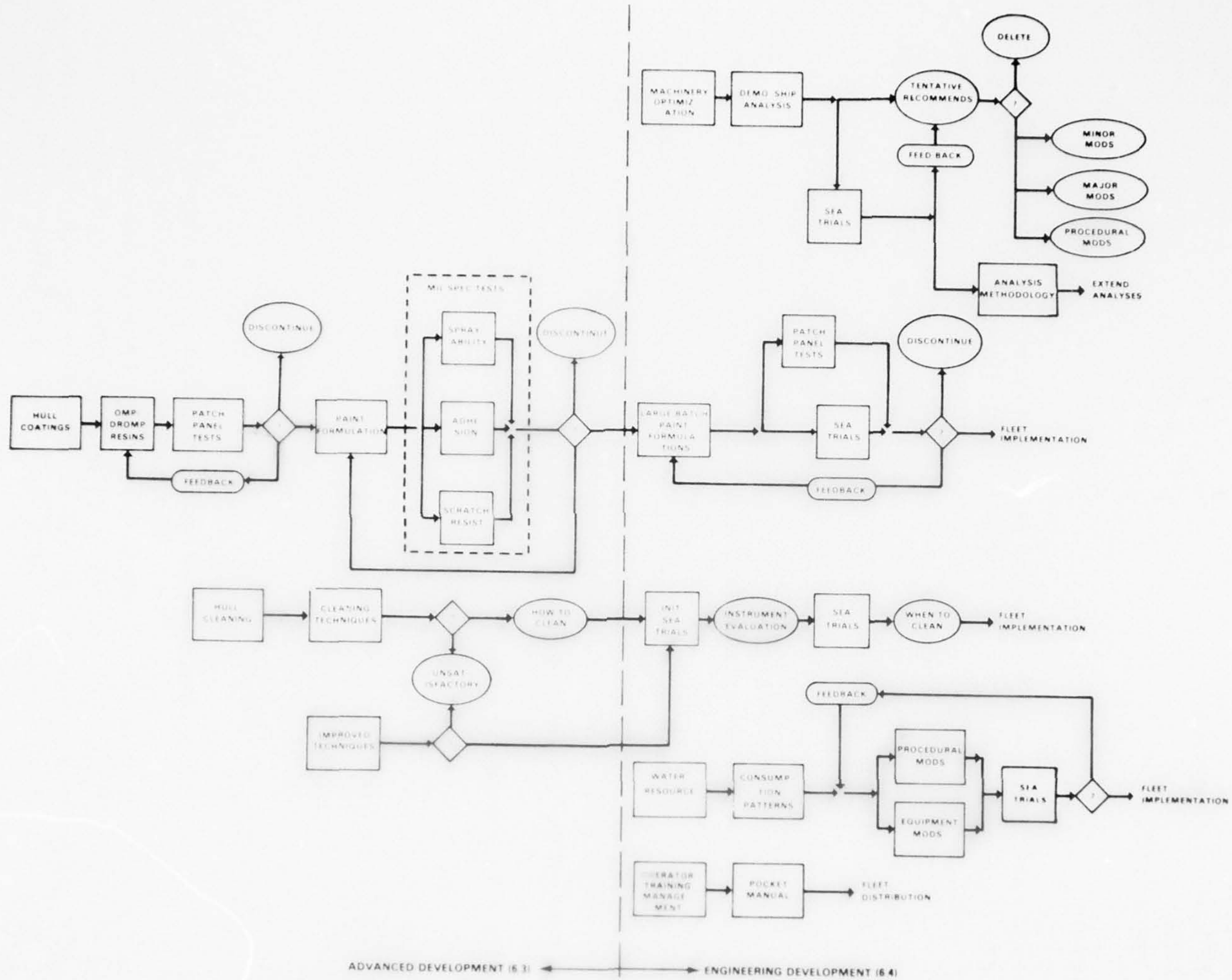


Figure B-5. EXISTING/FUTURE FLEET ENERGY CONSERVATION

Hull Maintenance

Objective

This subtask provides the engineering development for the hull cleaning and hull coating work units described under the NAVSEA conservation portion of 63724N, Z0829. The specific objective is to provide for at-sea testing of improved hull maintenance (coatings and cleaning) technologies.

Technical Approach

Hull Cleaning

The FF 1052 class has been selected for the hull cleaning program primarily because its mission profile is representative of that of the largest number of Navy ships and because a minimum of instrumentation is required for conducting trials on this ship type (one instrument per shaft). The hull cleaning trials are to be conducted in two phases. Phase I involves pier-side instrumentation, hull cleaning, and underway testing of a large number of Navy ships particularly immediately before routine drydocking so that critical evaluation of the cleaning effectiveness can be made. Phase I is designed to answer the question of how to clean ships hulls, as a function of both the state of fouling and the method to be used in cleaning. As part of their routine drydocking and overhaul schedule, up to 15 ships will undergo selected underwater cleaning. On drydocking shortly after cleaning, an evaluation will be made of the effectiveness of the cleaning method as well as the documentation of any detrimental effect on the paint system itself.

Phase II of the trials plan is a 2-year evaluation to determine the cost-effectiveness of the underwater cleaning techniques in the field to answer the question of when to clean. The speed and shaft horsepower measuring instrumentation will be installed and left aboard four ships for a 2-year period to permit the ship to monitor the effects of fouling at convenient times during the ship's deployment.

Short power trials are routinely scheduled at about 30-day intervals, and the collected data forwarded to DTNSRDC for analysis. When the power required for a given ship speed increases above a predetermined value, DTNSRDC personnel will assist in conducting a detailed power trial aboard the test ship. Underwater cleaning of the test ship will then be done and a postcleaning power trial conducted to assess the effects of cleaning. Reference and test ship power levels will be compared during the 2-year test period. This approach should give a realistic estimate of the relative fuel and cost savings that can result from regular underwater hull cleaning.

Based on results from the laboratory and field studies, fleet implementation guidelines for underwater hull cleaning will be prepared and issued.

The hull cleaning program will be conducted as a controlled experiment. An exacting controlled experiment is not possible with commissioned ships; however, a reference ship and a "cleaned" ship will be tested through Phase II to determine the comparable effect of fuel savings with scheduled frequent cleaning against fuel requirements without hull cleaning for the 2-year test period. A reference ship and cleaned ship are to be selected from the Atlantic Fleet and another pair of test ships are to be selected from the Pacific Fleet. Each pair of test ships will be carefully selected on the basis of identical class, similar mission requirements, and similar deployment schedules. This approach should provide a realistic basis for estimating the fuel and cost savings that can result from regular hull cleaning and a broad sampling basis by using ships from the Atlantic and Pacific Fleets.

Hull Coatings

The approach for the advanced antifouling hull coatings effort is to synthesize organometallic polymer (OMP)-based paints from previously synthesized OMP resins. The OMP-based paints are undergoing laboratory tests for compliance with current military specifications. Small batch formulations are being procured for patch-panel static immersion tests and shipboard application evaluation. Up to 20 ships will have waterline-to-keel belly stripes applied with the OMP-based paints while drydocked as part of the normal overhaul schedule. The coatings will be monitored to determine their antifouling performance.

Special application coatings designed for use on propellers and sonar domes are being developed by chemically altering commercially available and laboratory-synthesized polyurethane and epoxy resins to incorporate OMP antifoulants. Once synthesized into paints, the performance of these coatings will be laboratory tested for compliance with current military paint specifications and will be evaluated for antifouling effectiveness through patch-panel static immersion tests. If acceptable, sufficient paint quantities will then be procured to conduct shipboard evaluations.

FY 1976/77 Progress

Hull Cleaning

The rotary-brush cleaning method was selected for evaluation as a result of a survey of hull-cleaning technologies, and the "how to clean" demonstrations done in early 1976. Two commercially available rotary-brush cleaning systems—Scamp and Brush Kart—were chosen for testing. A sea-trials program was approved and instrumentation was selected and procured for the shipboard trials.

Phase I trials were conducted on the U.S.S. Holt (FF 1074) during May and June 1976. Ships for the Phase II trials were selected: U.S.S. Trippe as the reference ship and U.S.S. Blakely as the test ship from the Atlantic Fleet, and U.S.S. Whipple as the reference ship and U.S.S. Stein as the test ship from the Pacific Fleet.

Phase II trials were started in August 1976. The status of the trials is:

PHASE II HULL CLEANING TRIALS STATUS

Ship	Time Since Drydock[a]	First Power Trial	Underwater Hull Cleaning	Second Power Trial
Atlantic Fleet				
U.S.S. Blakely (FF 1072)–Test	6 months	8/5/76	9/77	9/77
U.S.S. Trippe (FF 1075)–Reference	4 months	8/28/76	–	8/77
Pacific Fleet				
U.S.S. Stein (FF 1065)–Test	4 months	12/3/76	9/77	9/77
U.S.S. Whipple (FF 1062) Reference	11 months	11/18/76	–	9/77

[a]Drydocking included hull cleaning and painting.

An evaluation of the Sperry Doppler ship's speed sensor to ascertain repeatability and accuracy was initiated as part of the sea-trials effort. A new sensor, which could be installed from within the ship, was designed and fabricated. This will reduce the complexity and trial time required.

Hull Coatings

BUMED approval for antifouling coating application to ships hulls was obtained and eight ships have received belly stripe applications.

Of the 150 OMP resins that were synthesized, four have shown satisfactory antifouling characteristics through 5 years of patch-panel immersion tests. These are the base materials for the small-batch formulation of improved antifouling paints for shipboard evaluations. Shipboard evaluations were started in 1976. Laboratory tests and evaluation of drag-reducing organometallic polymer (DROMP) paints and special application antifouling paints for use on propellers and sonar domes have been underway and will be continued in the advanced development (Category 6.3) program in FY 1978.

Planned Milestones (Completion Dates)

Hull Cleaning

–Conduct Phase II sea trials on Atlantic Fleet ships (U.S.S. Trippe and U.S.S. Blakely) and Pacific Fleet ships (U.S.S. Stein and U.S.S. Whipple).
–Conduct hull cleaning and sea trials on other ships.
September 1977–Prepare interim fleet instruction on "How to Clean" ships hulls.
September 1978–Prepare interim fleet instruction on "How and When to Clean" ships hulls.
September 1979–Prepare final fleet instruction on hull cleaning.

Hull Coatings

September 1977–Begin shipboard antifouling applications and evaluation.
–Evaluate coating performance by diver inspection.
March 1978–Complete ship applications.
June 1978–Reformulate coatings.
January 1979–Prepare large batch formulations
June 1979–Ship test large batch formulations.
June 1981–Issue recommendations for fleet implementation.

Machinery Optimization

Objective

The objective is to reduce the fuel consumption of existing steam-powered ships by at least 10 percent through the identification of energy-intensive machinery systems and operational procedures and the recommendations of modifications to effect major energy savings.

Technical Approach

The following procedure is being used to analyze the FF 1052 class ship.

- Energy consumption/distribution patterns for the boiler plant and steam systems are being analyzed based on design data.
- Energy usage patterns are being corroborated using detailed operating logs, instruction manuals, past empirical analyses, and ship visits.
- Realistic quantified energy utilization profiles are being determined for various missions, total steaming hours, effects of degraded machinery conditions, and individual operational preferences.
- Based on these analyses, preliminary recommendations supported by cost information are formulated for procedural and equipment modifications.
- NSRDC and contractor personnel are conducting a series of underway measurements to verify the estimates made in the analyses using a trial plan.
- A series of recommendations was forwarded to NAVSEA for consideration for fleet-wide implementation.
- The methodology is documented so that it can be used to extend the analyses to other ship classes.
- Sea trials are being conducted in two phases: Phase I trials are being conducted at various speeds and under normal operating conditions to represent typical underway fuel consumption rates; Phase II trials are being conducted under controlled conditions to determine the amount by which fuel consumption can be reduced as a result of improved operating procedures.

The identification of energy-intensive machinery systems under the machinery optimization task will lead to recommendations for minor and major equipment and procedural modifications based on the cost-effectiveness of the modification when amortized over the remaining operating life of the ship. Minor equipment modifications are those that can be accomplished without restricting the availability of the ship. Major equipment modifications are those that have to be done during ship overhaul. Procedural modifications refer to changes in existing machinery operating practices that can be done without lessening the degrees of operational readiness.

Preliminary recommendations are subjected to sensitivity analyses to determine design feasibility, cost-effectiveness, and universality of applicability.

FY 1976/77 Progress

Heat-balance analyses based on design data, technical documentation, previous sea trials, and certification data of a demonstration ship were completed for the FF 1052 class. The analyses were performed by adapting a MARAD computer program to the FF 1052 class steam cycle. A determination was made of the power plant operating characteristics and fuel consumption over the mission profile from 8 knots to full power, in 2-knot increments.

A sea-trial plan was developed and the necessary instrumentation was determined to quantitatively verify energy usage profiles at various steaming conditions. Phase I trials involve normal steaming power at various speeds with machinery aligned in accordance with standard operating procedures. Phase II trials involve steaming at the same power levels as Phase I, but with boiler excess air maintained at 15 to 20 percent; one ship service turbine generator on-line; one forced draft blower per boiler; standby main feed pumps taken off-line; and all pressures and temperatures set according to design conditions. For each phase, flow rates, shaft torque, boiler excess air, condenser vacuum, and subsystem temperatures and pressures are measured at each speed.

Phase I and II trials were conducted 27 September through 2 October 1976, on the U.S.S. Holt (FF 1074). Preliminary results indicated that the fuel consumption rate in Phase II (controlled conditions using improved operating procedures) was significantly lower than the fuel consumption rate in Phase I (normal operating conditions), particularly in the cruising range of the ship. Phase II fuel consumption was 16.7 percent lower at 12 knots and 10.6 percent lower at 16 knots. Heat-balance calculations were completed and a final report was prepared detailing recommendations for energy-conserving equipment and procedural modifications.

Methodology was developed to extend the FF 1052 class analyses to other ship classes and a trials plan was developed for follow-on cruiser/destroyer steam plants.

Sensitivity analyses were conducted for the FF 1052 class recommendations of electrically-driven standby main feed pumps, waste heat feedwater heater, and anchor power diesel generator set.

Planned Milestones (Completion Dates)

October 1976–Complete FF 1074 sea trials.
March 1977–Complete FF 1074 analysis and recommendations.
April 1977–Complete analysis of DDG-2, DD-945, and DDG-35.
May 1977–Complete trial plan and follow-on trials.
October 1977–Complete FF 1074 follow-on trials.
October 1977–Complete analysis of DDG-37, CG-16, and CG-26.

December 1977–Complete sensitivity analyses, and FF 1074 recommendations.
April 1978–Complete analysis of CV-59 and CV-63.
December 1978–Complete major auxiliaries.
December 1979–Complete major amphibious ships.

Feedback-Limited Combustion Control System

Objective

The objective is to develop a fully automatic combustion control system based on the oxygen analysis principle that will maintain boiler combustion air at peak efficiency during all conditions of demand. Current distillate fuels render present techniques inadequate for optimum combustion control. This new technique will result in a 7 to 15 percent reduction in fuel consumption on major ship classes.

Technical Approach

Based on laboratory and shipboard experience on oxygen analysis, a specification will be prepared to procure two analyzer systems for use on 1,200 psi plants: (1) based on in situ analyzers, and (2) based on extraction techniques. Analyses, including operations evaluation, will be conducted, leading to fleet implementation.

FY 1976/77 Progress

Laboratory instruments were evaluated on shipboard and shore-based boilers. A procurement specification and program plan for test and evaluation were prepared.

Planned Milestones (Completion Dates)

January 1977—Award systems contracts.
June 1978—Receive systems.
September 1978—Complete preliminary checkout.
December 1978—Install system on board ships.
June 1979—Complete operations evaluation.
March 1979—Recommend for fleet implementation.

Conservation
Category 6.4
NAVSEA

2000 kw Quiet Diesel Generator

Objective

The objective is to procure, test, and evaluate a quiet diesel generator set suitable for installation on ASW combatants.

Technical Approach

The noise reduction requirements will be determined for diesel engines when utilized as prime movers for electrical generators. The state-of-the-art of noise isolation techniques will also be determined. An RFP will be prepared for procurement of a quiet diesel generator, test and evaluation will be performed, and recommendations for fleet implementation will be made. This effort is an outgrowth of survey and assessment studies made under 62765N.

FY 1976/77 Progress

A program plan and preliminary noise analysis were completed. A task was issued for preparation of an RFP for procurement of a diesel generator set.

Planned Milestones (Completion Dates)

September 1977–Complete project plan.
September 1977–Complete noise analysis.
December 1977–Complete RFP.
April 1978–Award contract.
December 1978–Receive system.
June 1980–Complete operations evaluation.
September 1980–Recommend for fleet implementation.

Water Resource Management

Objective

DTNSRDC is identifying freshwater flow patterns aboard ship and formulating water resource management techniques to improve the efficiency of freshwater production and utilization aboard ship.

Technical Approach

Existing processes, operations, and activities consuming fresh water will be analyzed on an FF 1052 class frigate and an aircraft carrier. The areas where water use reduction is possible will be identified and impact assessed.

After identifying potential payoff areas, studies will be conducted leading to recommendations for specific equipment and procedural modifications. These proposed modifications will then be reduced to practice and their effectiveness measured.

FY 1976/77 Progress

Shipboard freshwater use patterns identified by an existing water pollution data base have been extended to determine detailed energy use. Further determination will be made through the installation of 100 water flow meters on the U.S.S. Saratoga (CV 60) and 25 water flow meters on the U.S.S. McCandless (FF 1984). Flow meter installation has been completed.

A plan for testing and evaluating a commercially available laundry-water recycling system was completed. In initial tests, laundry water was cleaned and recycled 50 times, reducing consumption of fresh water 88 percent and chemicals 50 percent. Detailed laboratory investigation is complete.

Candidate waste treatment systems were analyzed to determine the cost of freshwater production. A life-cycle cost analysis was completed and the results of the total waste recycle system were summarized.

Planned Milestones (Completion Dates)

- Complete laundry rinse water reuse laboratory evaluation.
- Analyze Saratoga and McCandless data.
- Install water storage control system (some shipalts dump to bilge).
- Identify additional ships for limited trials.
- Prepare draft of fleetwide water management plan.
- Complete water conservation education film.

–Prepare plans for water conservation backfits kits.
–Install laundry water reuse system on U.S.S. Saratoga.
–Install photo print rinse system on U.S.S. Saratoga.

Conservation
Category 6.4
NAVSEA

Shipboard Machinery Performance Monitoring

Objective

The objective is to provide diagnostic information on ship operators concerning hull and power plant condition, thereby enabling immediate rectification of the effects of system malfunction/degradation and elimination of increased fuel consumption.

Technical Approach

NAVSEA will determine the minimum amount of data required to give an indication of shipboard system condition and will design and evaluate a system to readily provide the necessary information.

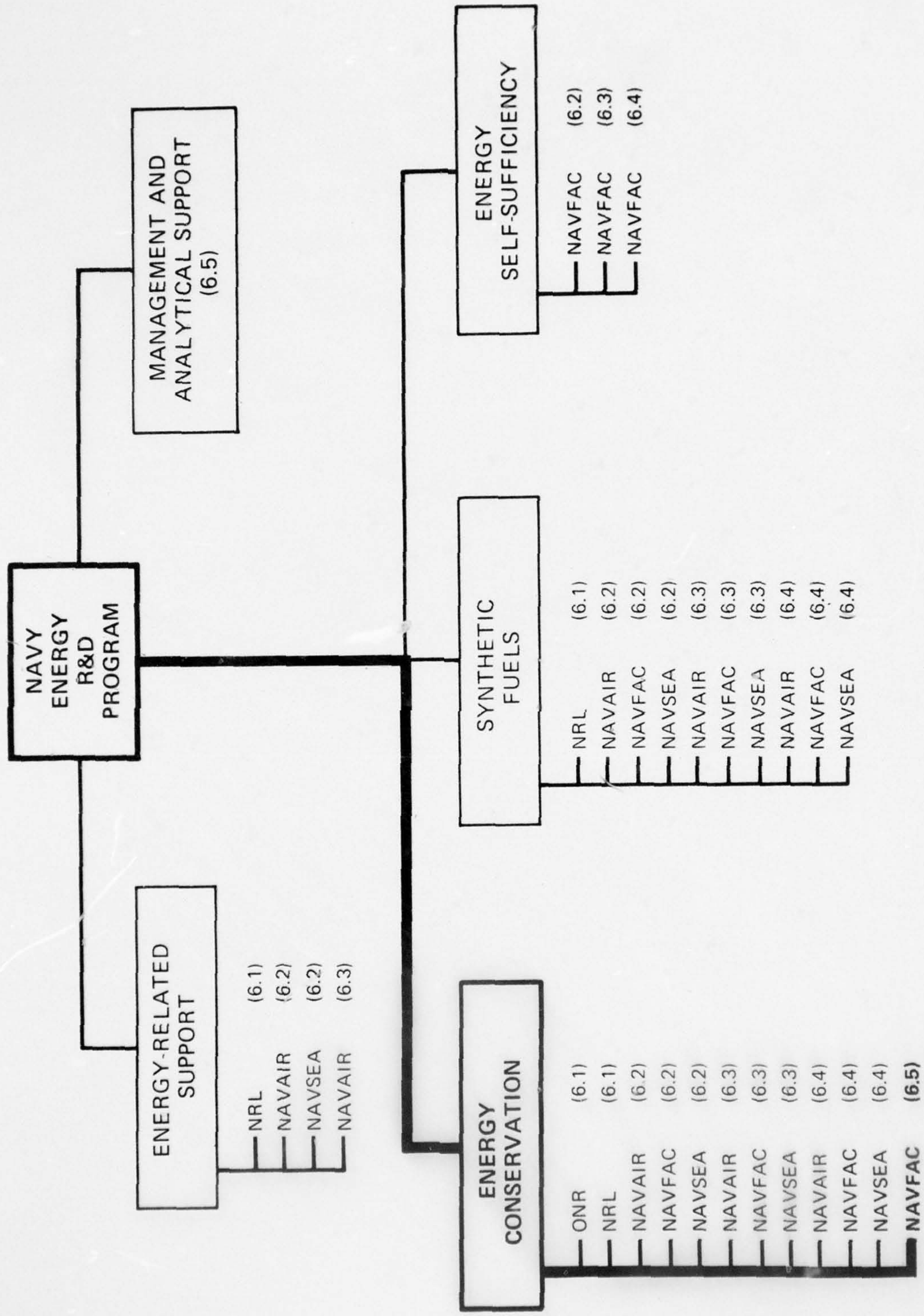
FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

December 1977—Issue RFP.
April 1978—Award contract.
December 1978—Design analysis.
June 1979—Complete system development.
September 1979—Install aboard ship.
January 1980—Make recommendations for implementation.

ENERGY CONSERVATION
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
NAVFAC


NAVY ENERGY R&D PROGRAM
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
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ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
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2.6 MANAGEMENT AND ANALYTICAL SUPPORT (6.5)

2.6.1 NAVFAC
Shore Facilities Energy Conservation
P.E. 65861N

Introduction

The projects contained within this RDT&E category encompass Navy in-house management of the energy R&D program and include conservation analyses and studies necessary to support this management.

Energy Usage Statistics for Sewells Point

Objective

The site characteristics of Sewells Point Navy Base will be determined to characterize energy usage.

Technical Approach

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones

Milestones for this project are yet to be determined.

Review of Guidance Governing Centralized Steam and Electric Power Generation by Naval Installations

Objective

The objective is to review Navy policy governing central steam and electric power generation in light of current fuel costs and projected escalation.

Technical Approach

The industrial and commercial guidance established by the Navy governing centralized steam and electrical power generation by naval installations should be reviewed in light of present day fuel costs and projected escalation. The study involves two major areas of concentration: centralized steam generation compared with replacement of many small existing boilers, and continued purchase of electric power versus central generation at a Navy base. Since the Navy is actively attempting to convert from oil and natural gas to coal, this study should be based on a conventional pulverized coal unit with both particulate and sulfur oxide control.

FY 1976/77 Progress

A contract statement-of-work for the study was prepared. The work will be done in three phases. Phase I, covering existing boilers and steam-turbine generators, will involve a general study of on-base electric power and steam generation and a site-specific analysis at two shipyards. Phase II will include preparation of preliminary designs and parametric analyses of system performance and cost for both new central and decentralized steam plants with flue gas desulfurization. Phase III calls for cost-effectiveness studies to determine if electric power should be generated in addition to heat and process steam at new central plants. Only Phase I will be done in FY 1977.

Planned Milestones (Completion Dates)

December 1976–Prepare contract schedule for guidance study.
July 1977–Award contract for Phase I.
November 1978–Award contract for Phase II.
November 1978–Monitor contract and publish report for Phase I.
November 1979–Award contract for Phase III.
FY 1978-80–Monitor contract and publish reports.

ENERGY CONSERVATION DOCUMENTATION

2.7 DOCUMENTATION

Office of Naval Research (Contact: J. Satkowski–202-692-4406)

"Light Scattering Characterization of the Structural Relaxation Dynamics in a Methylphenylsiloxane Fluid," C. J. Montrose, R. P. Moeller, and B. E. Dom, November 1976.

"Progress in the Development and Utilization of Ferrography," V. C. Westcott, December 31, 1975.

"Status Report to 30 June 1976," under ONR Grant N00014-76-G-0019, September 20, 1976.

"The Role of Temperature in EHD," J. W. Kannel, October 22, 1976.

"The Conflicting Roles of Carbontetrachloride as a Boundary Lubricant," T. Shirakashi, T. Komanduri, and M. C. Shaw, Carnegie-Mellon University, March 31, 1977.

"Dynamical Shear and Structural Viscoelasticity in Elastohydrodynamic Lubrication," C. J. Montrose, C. T. Moynihan, and K. Sasabe, May 1977.

"Experimental Observation of Thermoelastic Instability in Lubricated Sliding Between Solid Surfaces," B. N. Banerjee and R. A. Burton, January 21, 1976.

"Relationship Between Wear and Self-Generated EMF's During Sliding Under Conditions of Boundary Lubrication," January-May 1976.

NAVFAC (Contact: W. Adams–703-325-8535)

"Solar Heating of Buildings and Domestic Hot Water," TR-835, E. J. Beck, Jr., and R. L. Field, January 1976, revised April 1976.

"Metal Hydrides for Energy Storage Applications," TN-1393, S. C. Garg and A. W. McClaine, June 1975.

"Energy Utilization of Solid Waste at Small Naval Bases—An Economic Decision Model and Comparison of Two Types of Systems," TN-1465, P. L. Stone, December 1976.

"Portable Gas Analyzers for Boiler Monitoring," TN-1454, R. S. Chapler, September 1976.

"Technical Evaluation of Water/Energy Saving Shower Heads for Naval Supply Center, Oakland," TM-64-75-1, J. L. Squier and C. K. Smith, December 1975.

"Cost-Effectiveness Analysis of Lubricant Reclamation," TM-64-76-1, C. W. Anderson, January 1976.

"Conceptual Design and Evaluation of an Organic Rankine Cycle Bottoming System for the Diesel-Electric Power Plant at the Naval Radio Station (T) Cutler, Maine," TM-63-76-9, R. E. Kirts, June 1976.

"Possible Application of Heat Pumps," TM-80-76-1, E. J. Beck, August 1976.

"Pay-Off Period Estimator for Energy-Saving Concepts," TM-06-76-1, M. L. Eaton, June 1976.

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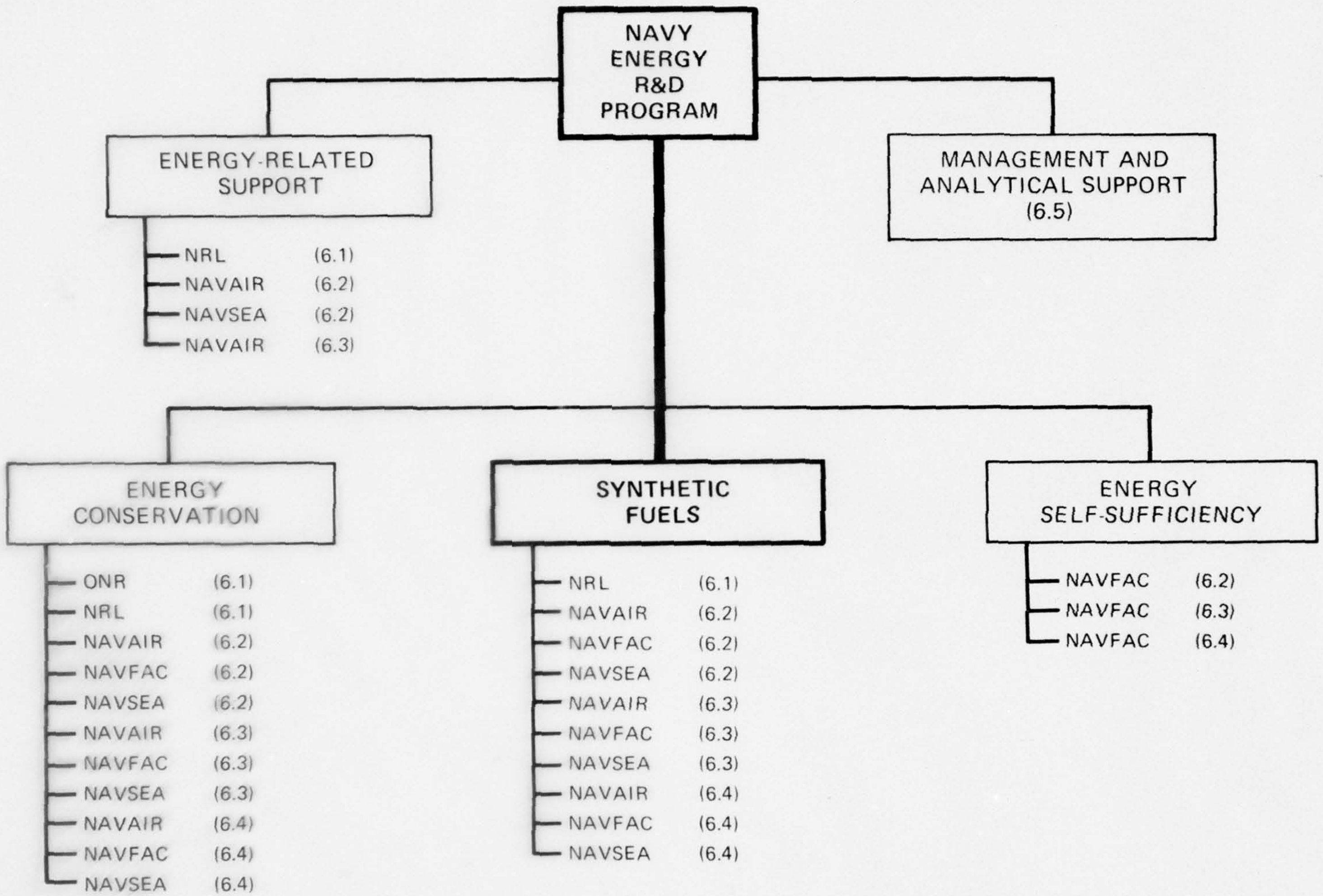
SYNTHETIC FUELS


NAVY ENERGY R&D PROGRAM
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY CONSERVATION
ONR (6.1)
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NAVAIR (6.2)
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SYNTHETIC FUELS
NRL (6.1)
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NAVSEA (6.4)
ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
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NAVFAC (6.4)

3.0 SYNTHETIC FUELS

3.1 INTRODUCTION

Recent studies of the extent of world petroleum resources have generally concluded that planning should be based on an expectation that petroleum resources will be exhausted in this century. Since fuels produced from petroleum are vital to naval operations, the expectation of near-term depletion of petroleum must play an important role in Navy R&D planning. Continued use of hydrocarbon fuels by the Navy through the end of the century is a certainty; therefore, the primary concern is continued availability, even though the price will probably be high.

There are large domestic resources of oil shale, tar sands, and coal from which hydrocarbon fuels could become available. These resources in the United States will not be depleted for a century or more. Even after the fossil sources are depleted, hydrocarbon fuels could be produced by direct synthesis.

Thus, the basic approach of the Navy synthetic fuel strategy is directed toward ensuring the continued availability of hydrocarbon fuels. Immediate emphasis is being placed on the fuels that are now becoming available from nonpetroleum fossil sources. Extensive national R&D programs are currently being directed toward the exploitation of these resources. The Navy's approach is to (1) ensure that the Navy is an informed customer, (2) ensure that the products that result from the national synthetic fuel program will be suitable for naval needs, and (3) promote a viable federal program to establish a commercial synthetic fuel production capability.

Improved oil shale and coal processes are entering the pilot plant stages. The construction of pilot plants in the United States is being delayed by capital requirements, legal restrictions, environmental constraints, and policy deliberations. However, commercial oil-shale plants are expected to begin operation in the 1980s and a significant tar sands industry in Canada may be in operation by the early 1980s.

Coal requires considerable hydrotreating to produce middle-distillate fuels, but liquid feedstocks from coal are an excellent source of gasoline. The most practical approach to produce middle-distillates and gasoline would be to convert less petroleum into gasoline and use coal-derived crude oil to make up the difference, leaving more petroleum available for middle-distillate fuels production. Therefore, synthetic fuels derived from coal may not be practical for widespread Navy use for some time, and certainly not until the need for gasoline as a transportation fuel has abated.

3.2 SYNTHETIC FUEL AVAILABILITY

The availability of test quantities of synthetic fuels and projected full-scale production dates must be determined so that the Navy can plan for test and evaluation and introduce the fuels to fleet use. Figure B-6 shows the projected availability of synthetic fuels.

Two considerations are important to the Navy's R&D plans for synthetic fuels: considerable lead time (3 to 4 years) is necessary to conduct test and evaluation programs to ensure that fuels and hardware systems are compatible, and the Navy's participation in a test and evaluation program is essential to demonstrate to other federal agencies, primarily ERDA, that there will be a market for a full slate of synthetic fuel products suitable for Navy applications.

3.2.1 Synthetic Fuels Derived From Oil Shale

In 1975, various military operational fuels (JP-4, JP-5/Jet A, DFM/DF-2, gasoline, heavy fuel oil) were produced from 10,000 barrels of crude shale oil in a commercial small-scale refinery having a capacity of about 9,000 barrels per stream day.

The crude shale oil was produced by the Paraho process in a 56-day run using shale mined from the Naval Oil Shale Reserve located at Anvil Points, Colorado. The crude shale was processed in a commercial refinery on a "best efforts" basis. The input of 9,956 barrels of crude shale oil yielded 5,765 barrels of various military fuels, of which 5,108 barrels were shipped for testing:

	Motor gasoline	JP-4	JP-5/ JET-A	DFM/ DF-2	Heavy fuel oil
Army	463			131	
Navy			409	759	1120
Air Force		347			
NASA			157		
ERDA	181				
Coast Guard				141	
MARAD					1400
Total	644	347	566	1031	2520

The fuels were distributed to various government and private laboratories for specification tests, post-processing studies, combustor tests, engine tests, burner tests, and full-scale tests. The fuels met a majority of the standard specification requirements; the feasibility of using crude shale oil as a feedstock for military fuels was demonstrated. However, the fuels exhibited storage problems and a degree of thermal instability. They also showed a high-wax and a high-gum content, as well as a high concentration of nitrogen and particulate matter.

In cases where specifications were not met, further studies were conducted to determine why the fuels were not within specification limits and what types of treatment

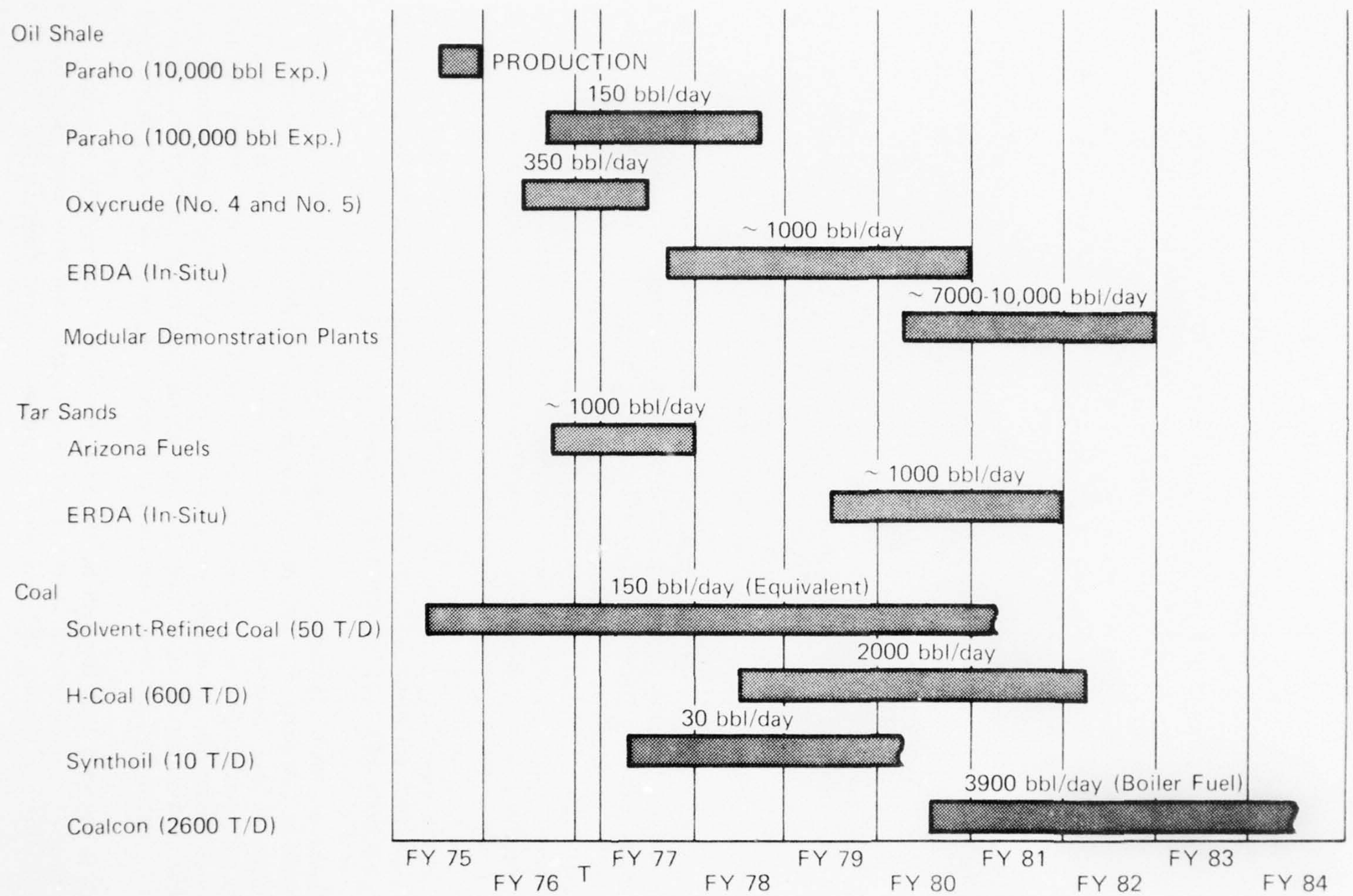


Figure B-6. SYNTHETIC CRUDE PRODUCTION SCHEDULE

would be effective in improving the fuel properties. Tests were made to determine how compatible the shale derived fuels are with petroleum based fuels and with the materials that are commonly found in engines and fuel handling systems.

Hardware and engine tests were performed in assorted combustors, burners, internal combustion engines, and turbines to determine the performance and emission characteristics of the shale fuels and to compare them with similar petroleum fuels. Parameters measured included specific fuel consumption, thrust, flame radiation, and emissions of hydrocarbons, carbon monoxide, and oxides of nitrogen. Navy and DOD laboratories and several private contractors conducted the tests.

Full-scale tests were conducted to evaluate the overall performance of the synthetic fuels in operational hardware. Based on the results, the problems encountered with some of the physical and chemical characteristics of the fuels could probably be solved by some of the process operations inherent in a commercial, large-scale refinery.

A full description of the 1975 program, including data for the preprocessing studies and refinery yields, is in the contractor's report prepared for the U.S. Navy (MAT-08T3), "The Production and Refining of Crude Shale Oil Into Military Fuels, Final Report." In addition, a report describing the evaluation of these fuels in military systems and components, "Compilation of Oil Shale Fuels Test Results," was prepared.

Based on the results of the 10,000 barrel experiment and the encouragement of the Installation and Logistics (I&L) Office of DOD, the Navy should continue to serve as the focal point and coordinator of DOD efforts in synthetic fuels programs. The Navy (MAT-08T3) in its new management role, set up an interservice steering group to develop a synthetic fuel project to provide military fuels from domestic nonpetroleum resources. To conduct such a project, industry sources indicated that the optimum quantity of crude required in a commercial refinery would be about 100,000 barrels. This quantity of crude would permit having the required process operations (hydrotreating, hydrocracking, coking, etc.) to process the crude. The processing of this quantity of crude would make available the quantities of fuel needed to conduct full-scale testing and evaluation to qualify the fuels for operational use. This type of experiment would encourage industry to develop shale oil as a viable alternative to petroleum-based fuels.

Based on these arguments, a program has been developed. This program will be conducted in two parts. The first part would demonstrate that military operational fuels that meet all government specifications can be produced in a commercial refinery. The second part would refine, in a commercial refinery, crude shale oil into military specification fuels under the conditions and process schemes used in the demonstration. The tentative distribution of these fuels to the various government laboratories and contractors is shown in Table B-1. These fuels will probably be ready for testing in FY 1979.

It is expected that this will be the first of several experiments of this type, each addressing the various generic types of synthetic crudes that have early potential for commercialization. During the test and evaluation of these fuels by the SYSCOMs

Table B-1. DISTRIBUTION OF PRODUCTS FROM 100,000 BARREL PROGRAM
(Barrels)

Agency	Crude Shale Oil	AUGUS	MOGAS	JP-4	JP-5	JP-8	DFM	No. 6	Total
NAPTC	–	–	–	–	17,000	–	–	–	17,000
Air Force	–	–	–	2,100	20	70	20	–	2,210
NASA	–	50	–	1	50	1	50	50	202
NRL	–	–	–	–	10	–	–	–	10
Army	–	–	516	372	621	404	1,092	–	3,005
LERC	2	2	2	2	2	2	2	2	16
CEL	–	–	–	–	–	–	–	647+	647+
NSRDC	–	–	–	–	–	–	40,000	–	40,000
ERDA-BERC	2	–	170	20	5	1	20	1	219
Total	4	52	688	2,495	17,708	487	41,184	700	63,309
Percent of total	–	0.1	1.1	3.9	28.0	0.8	65.1	1.1	100.0

(NAVAIR, NAVSEA, NAVFAC) and other DOD laboratories, a second 100,000 barrels of synthetic crude oil could be purchased and refined. This crude could be generated by one of the in-situ techniques or other crudes may become available. (Table B-1 and Figure B-6 show that large quantities of coal-derived synthetic crudes could be available in FY 1978, 1979, and 1980 from both the H-Coal program and the Coalcon program.)

3.2.2 Synthetic Fuels Derived From Coal

The test and evaluation of fuels derived from coal will be determined by synthetic crude availability. The Navy or DOD will not be actively engaged in these programs until it is obvious that both ERDA and industry are interested in developing crudes into high-flash-point middle-distillate fuels.

At the conclusion of the test and evaluation program on military operational fuels derived from shale oil, the refining and testing of military fuels derived from coal will be started on a large scale to allow a complete evaluation of the fuels. If, as previously stated, ERDA and industry have shown interest in converting these crudes into middle-distillate fuels and have not decided that they could better serve the nation as sources for gasoline, petrochemical feedstocks, or utility boiler fuels, then they will be evaluated as sources for military operational fuels.

3.2.3 Synthetic Fuels Derived From Tar Sands

Currently Sun Oil Company's subsidiary, Great Canadian Oil Sands Ltd. (GCOS), has an operational synthetic crude plant in Canada that produces about 50,000 barrels a day. This plant was completed in 1968 and produces satisfactory synthetic fuels from tar sands. The test and evaluation of synthetic fuels derived from U.S. tar sands will be determined by the availability of the synthetic crudes.

3.3 GENERAL PLANS AND SCHEDULES

To support the continued availability of hydrocarbon fuels for fleet operational use, the major emphasis in FY 1977/78 will be the 100,000 barrel oil shale experiment. A majority of the advanced development (Category 6.3) funds will be invested in obtaining, refining, storing, transporting and distributing crude and refined products. Figure B-7 shows the projected status of the synthetic fuel test program.

The 100,000 barrel experiment will pace all of the synthetic fuel testing efforts. Currently available quantities from the previous 10,000 barrel experiment and some solvent-refined coal fuels will be subjected to additional laboratory tests through FY 1978. After refining the 100,000 barrels of oil-shale crude, preliminary laboratory tests and small-scale tests will be conducted in FY 1979 and full-scale tests will be initiated in early FY 1980.

Synthetic crudes from other domestic sources will be evaluated to determine their potential as an alternate source of hydrocarbon fuels for fleet operational use. The crudes will be evaluated to determine their physical and chemical characteristics. Some pilot plant studies may be done to determine the degree of refining required to make military operational fuels and the potential yield of these fuels from the crude.

Each command throughout the test and evaluation program will gather information to determine what changes or modifications, if any, need to be made to the current fuel specifications. A typical example is the aircraft turbine specification (MIL-T-5624J), which has no requirement for total nitrogen or fuel-bound nitrogen in the current specifications. Therefore, fuels with high-nitrogen content are within specification requirements although high-nitrogen content may have an adverse effect on performance.

The activity network of the project showing the flow of the project elements from exploratory development (6.2) through engineering development (6.4) is given in Figure B-8.

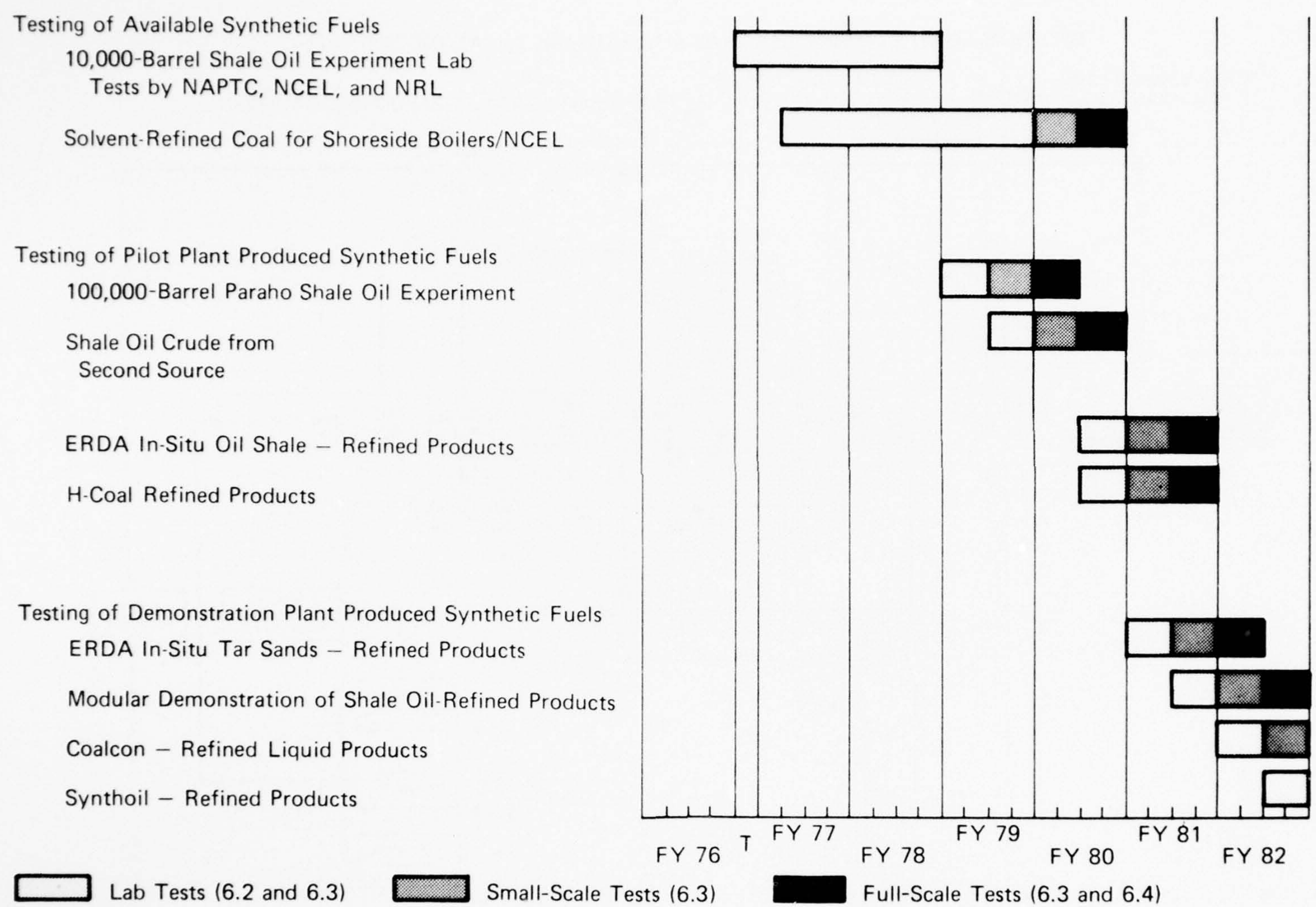


Figure B-7. PROJECTED STATUS OF SYNTHETIC FUEL TEST PROGRAM

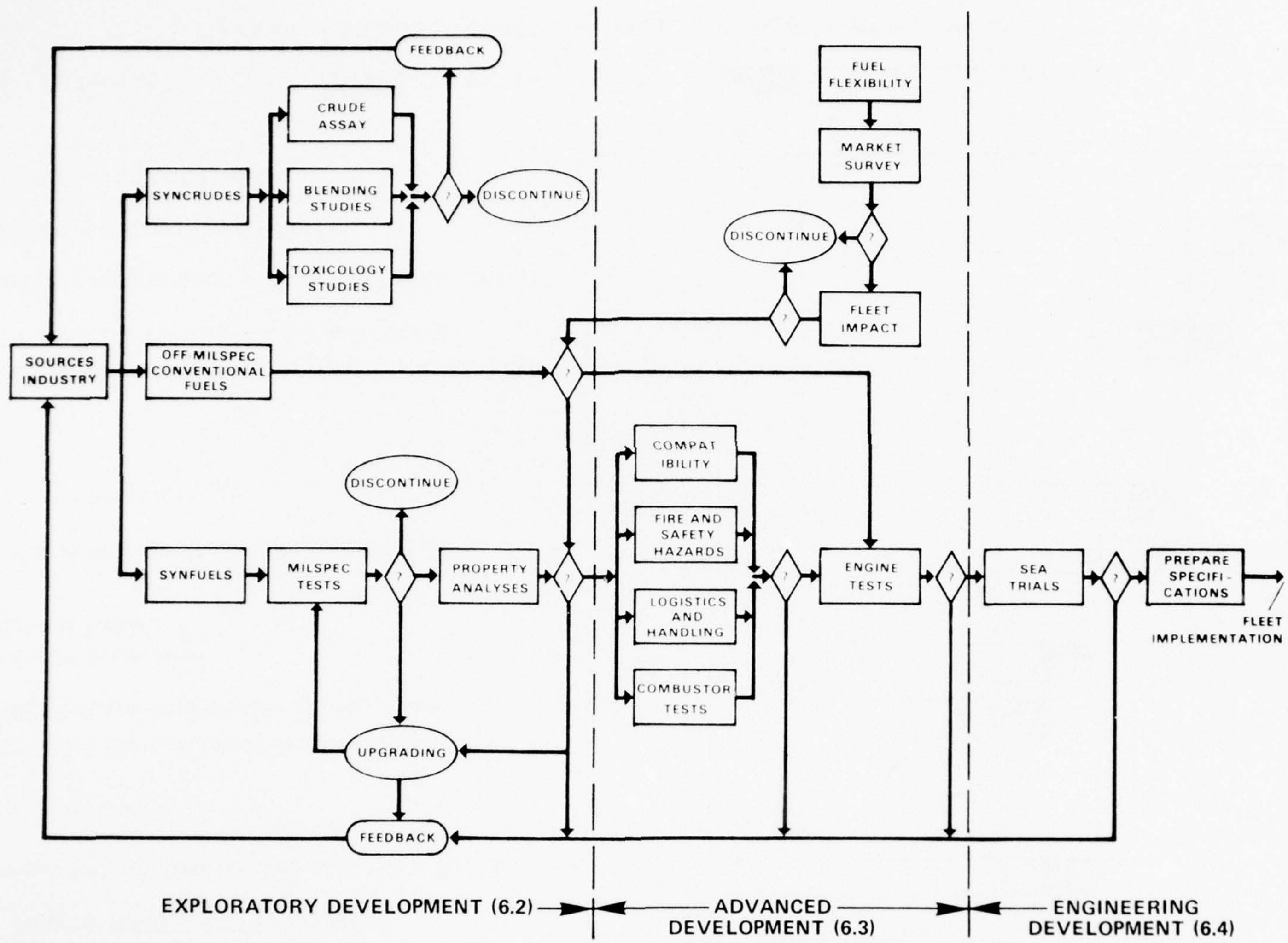
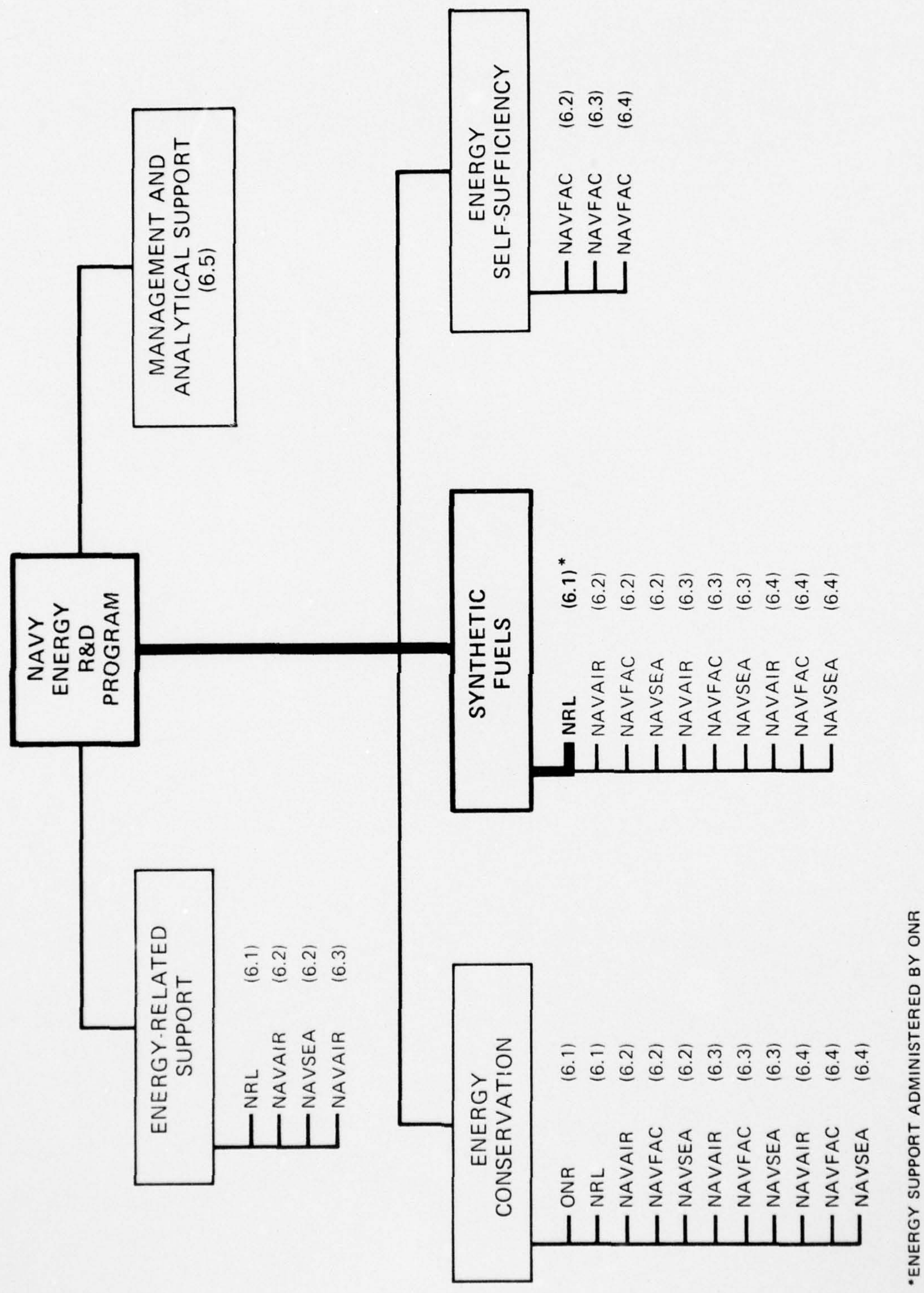


Figure B-8. ACTIVITY NETWORK OF SYNTHETIC FUELS R&D PROGRAM

SYNTHETIC FUELS
BASIC RESEARCH (6.1)
NRL


NAVY ENERGY R&D PROGRAM
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY CONSERVATION
ONR (6.1)
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SYNTHETIC FUELS
NRL (6.1)*
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NAVFAC (6.2)
NAVSEA (6.2)
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ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
NAVFAC (6.3)
NAVFAC (6.4)
*ENERGY SUPPORT ADMINISTERED BY ONR

3.4 BASIC RESEARCH (6.1)

3.4.1 NRL
Synthetic Fuels
P.E. 61153N-24
Project Number RR-024-02-41

Introduction

NRL is conducting an investigation into coal liquefaction processes. The process of particular interest uses controlled, low-temperature oxidation of coal to produce hydrocarbons of moderate molecular weight. This is an approach not currently under investigation by industry or ERDA.

Synthetic Fuel Process
Task Area RR 024-02-41
Work Unit: C01-14.101

Objective

The objective is to explore the effect of controlled low-temperature oxidation on reducing the molecular weight of coal and to assess the potential of partial oxidation for of coal.

Technical Approach

Coal is dissolved or suspended in a nonreactive solvent and oxidized with air at modest conditions. The oxidation products are subsequently decomposed in the presence (or absence) of air and/or catalysts. The molecular weight distribution of the products is determined by gel permeation chromatography, gas chromatography, and other techniques. Model compounds, which resemble molecular structures in coal, will be subjected to similar experiments to aid in determining the chemical mechanisms of the oxidation and decomposition reactions.

FY 1976/77 Progress

Solvent-refined coal has been dissolved in quinoline and oxidized with air at 110° C to 200° C. Oxygen absorption rate decreases with time. Thermal stress of oxidized coal samples has been conducted at 200° C to 425° C. Little reaction occurs below 350° C, but gas evolution increases above this temperature. The composition of the liquid phase changes above 400° C and up to 40 percent of intermediate range molecular weight products are observed for 2- to 5-hour stress periods at 410° C.

In preliminary work with pyridine, this coal solvent demonstrated excellent potential for coal fragmentation at significantly milder oxidizing conditions than those required with quinoline solvent.

Planned Milestones (Completion Dates)

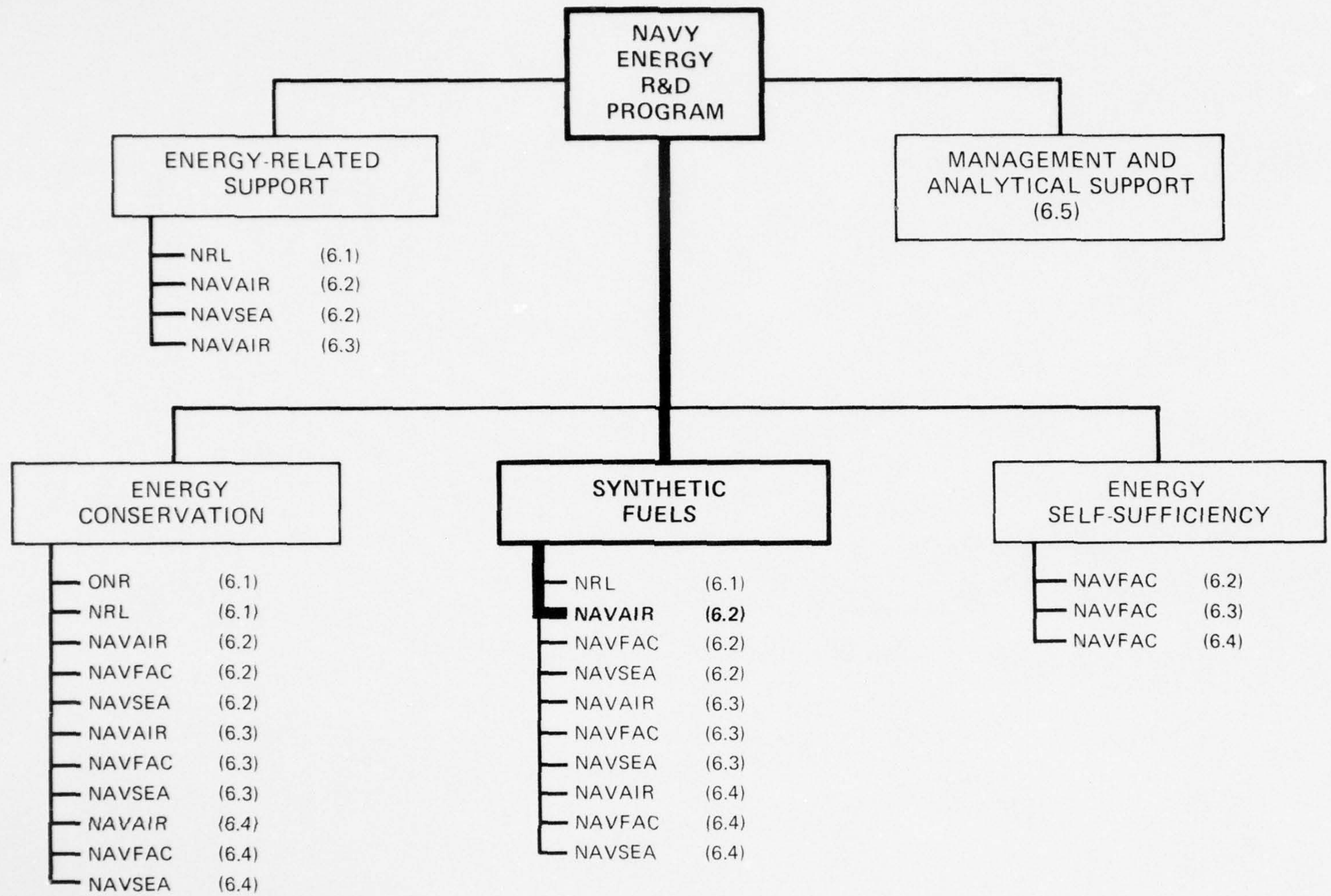
October 1977–Test additional coals with processes and at conditions found successful for solvent refined coal.

February 1978–Optimize the yield of low molecular weight products using pyridine as a solvent.

September 1978–Conduct combined coal oxidation/thermal stress reactions in a flow reactor.

Undecided–Stress coal in a radiation field in the presence of moderate to high pressure hydrogen.

SYNTHETIC FUELS
EXPLORATORY DEVELOPMENT (6.2)
NAVAIR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3.5 EXPLORATORY DEVELOPMENT (6.2)

3.5.1 NAVAIR
P.E. 62765N (AIR)

Introduction

The NAVAIR exploratory development effort is oriented toward the test and evaluation of synthetic jet fuels from alternative sources. The NAVAIR effort is coordinated periodically in sponsored group meetings with the Army Aviation System Command, NASA, and the Air Force Systems Command. The overall program involves testing synthetic jet fuels derived from oil shale, tar sands, and coal. The physical and chemical characteristics of various synthetic jet fuels are determined in the NAVAIR synthetic fuels program. Prior Category 6.2 efforts were conducted under Project Number F57-571-301.

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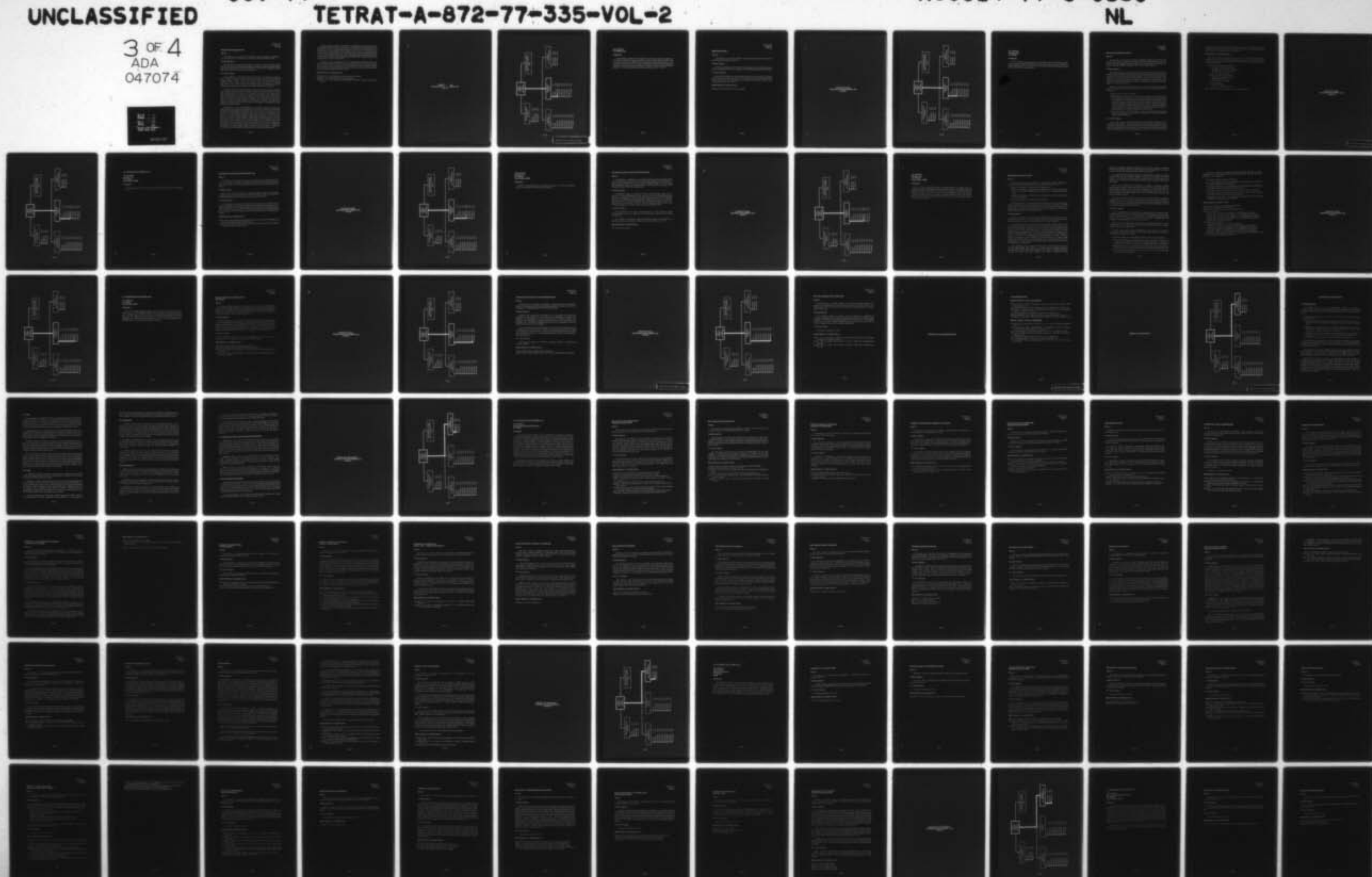


Energy Conversion/Synthetic Fuels

Objective

The objective is to evaluate the fundamental chemical and physical suitability of JP-5 fuel derived from coal, oil shale, or tar sands for aircraft propulsion systems.

Technical Approach

The physical and chemical characteristics of synthetic-derived and nonspecification aviation fuels will be determined and compared with those of military specification fuels. Distinctive characteristics of these fuels along with possible safety, handling, compatibility, and performance problems will be determined.

FY 1976/77 Progress

An investigation of the fuel-bound nitrogen problem is in progress. To date the major portion of the basic nitrogen compounds have been identified as highly substituted pyridine, boiling at 350° F to 475° F at 760 mm pressure. The upper boiling fraction starting at 475° F contains mostly alkyl quinolines. These compounds were evaluated with respect to their effect on fuel thermal oxidation stability by preparing blends of the isolated basic nitrogen fractions with an oil shale JP-5 depolarized with silica gel.

Various accelerated storage stability tests have been conducted to predict chemical effects resulting from the presence of nitrogen compounds in shale oil JP-5. It was found that a storage period of 26 weeks at 110° F (equivalent to 18-month real storage) did not induce unacceptable gum formation or sediment. An accelerated storage "quick test" (4 weeks at 140° F) has been completed; preliminary data indicate that an oil shale JP-5 refined to 4 ppm total nitrogen would be susceptible to the formation of hydroperoxides, which are harmful to neoprene elastomers in fuel pumps. Peroxides in general are also initiators for thermal oxidation reactions, which are responsible for producing fuel system deposits at high temperatures.

Through the use of gas chromatography, the n-paraffin content in synthetic fuels derived from coal, oil shale, and Canadian tar sand has been identified and quantified. The higher molecular weight normal paraffins have been related to the elevation of freeze points of the fuels through a correlation between the mole percent of hexadecane as a function of the reciprocal freeze point in degrees Kelvin. Attempts to lower the freeze point of a mixture of normal paraffinic hydrocarbons containing 20 percent sec-butyl benzene by the use of lower molecular weight normal paraffins has been successful. It was found that the addition of a C-13 normal paraffin at a concentration ratio of five times that of C-16 to a blend lowered the freeze point 15° F to 28° F. Applying this technique to actual fuels, however, was not successful. The apparent lack of response to the addition of normal paraffin implies that there are other classes of symmetrical molecules that are participating in elevation of the freeze point of the synthetic fuels.

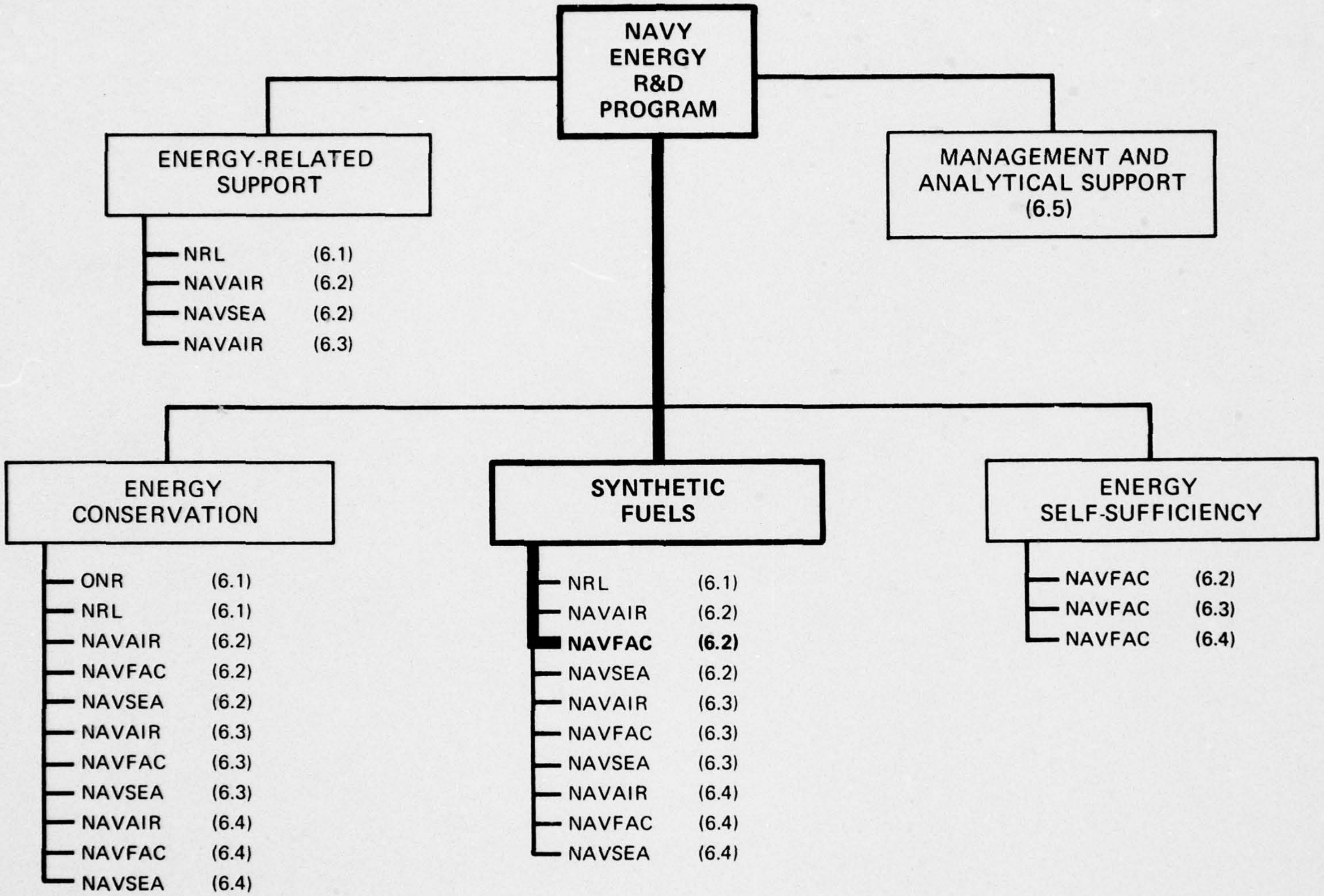
A small study was conducted to determine if nonspecification oil shale jet fuel could be comingled or blended with a conventional jet fuel without serious alteration of the properties of the latter. A thermal stability study was conducted on various fuel mixtures. It was found that a high quality JP-5 could tolerate only 15 percent of oil shale JP-5 that contained 116 ppm total nitrogen. The net dilution resulted in a fuel blend that contained 17 ppm nonbasic nitrogen. By contrast, earlier studies had judged a tolerable limit for total nitrogen content at about 70 ppm. Apparently the addition of the oil shale fuel had more of an antagonistic effect than a beneficial one.

Large-scale coalescer performance tests were conducted with oil shale derived JP-5; the water removing efficiency of the unit was below that observed in a petroleum fuel baseline run. It is not yet known whether the poor performance was caused by organic nitrogen content (990 ppm total nitrogen) imparting surface activity to the fuel or the basic composition of the fuel resisted the removal of free water.

Planned Milestones (Completion Dates)

February 1979—Evaluate fuels from oil shale and petroleum (DFM).
September 1979—Study properties of aircraft fossil fuels.
September 1979—Certify synthetic and nonmilitary specification petroleum fuels in Navy aircraft.

SYNTHET[illegible]ELS
EXPLORATORY D[illegible]PMENT (6.2)
NAVFA[illegible]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3.5.2 NAVFAC
P.E. 62765N (FAC)

Introduction

In the NAVFAC exploratory development effort, preliminary studies on residual fuel oil from the 10,000 barrel refining experiment on shale oil were conducted at CEL in FY 1975 under the work unit "Modification to Existing Shore Based Steam Generators." Data resulting from these laboratory and small-scale studies will be useful in further defining and carrying out the program currently planned for NAVFAC synthetic fuel studies. Previous Category 6.2 work was conducted under Task Area Number TA YF 57-571-999.

Waste/Fresh Oil Blends

Objective

The objective is to verify the ability to burn high concentrations of waste oils with good oil rather than dispose of the waste.

Technical Approach

Varying percentages of waste oils will be blended with good oil and burned in Navy boilers to determine performance characteristics. New blending techniques will be developed.

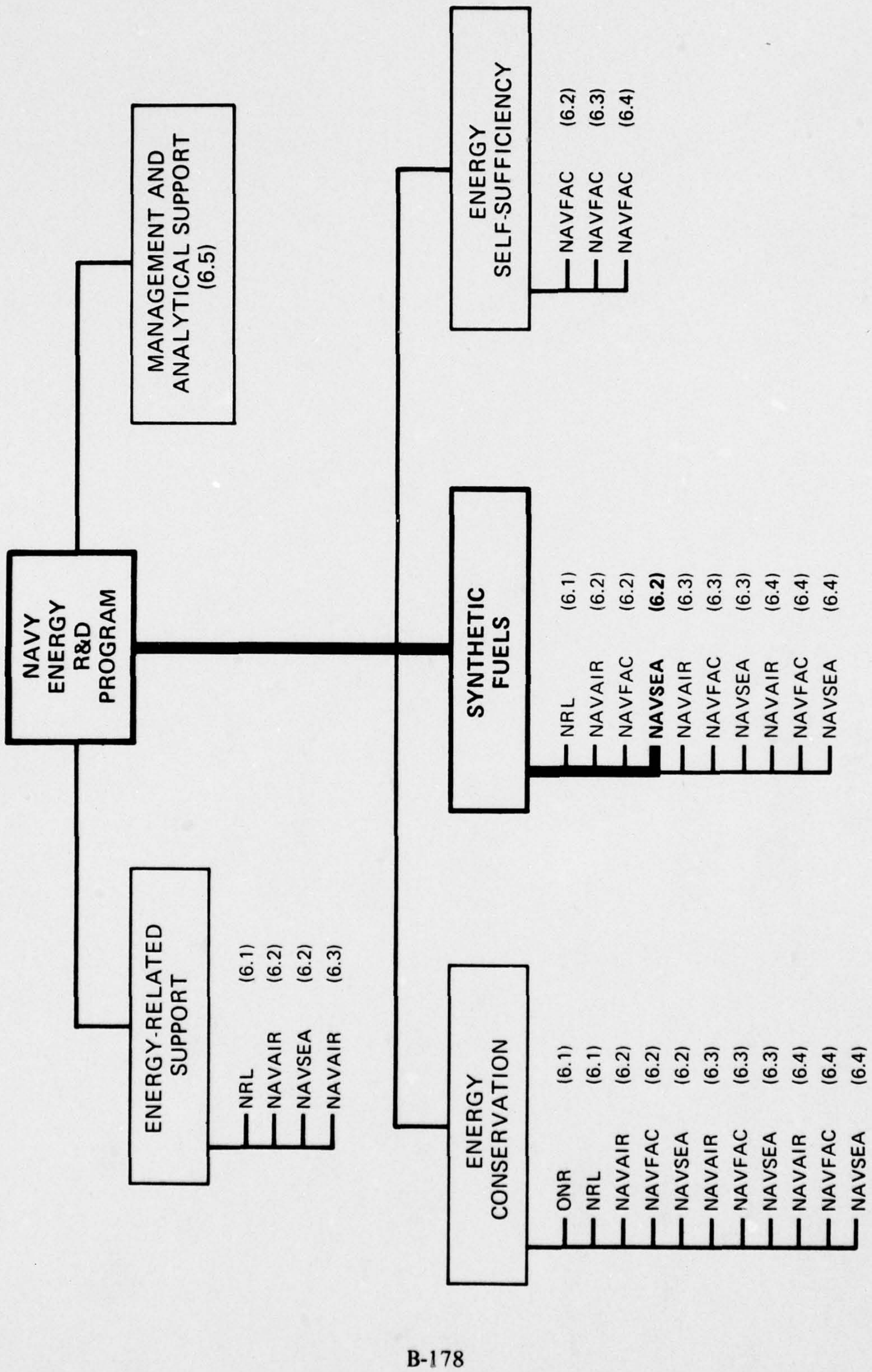
FY 1976/77 Progress

Storage and handling tests and small boiler firing tests were completed. Successful firing of waste jet fuel/fresh oil blends of up to 60 percent jet fuel were conducted. Blends (up to 30 percent) of waste ship fuel, however, presented burner problems, possibly caused by bilge accumulations in the waste oil.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

SYNTHETIC FUELS
EXPLORATORY DEVELOPMENT (6.2)
NAVSEA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3.5.3 NAVSEA
Synthetic Fuels
P.E. 62765N

Introduction

In FY 1976 Navy ships consumed over 20 million barrels of ND, DFM and NSFO, which represented nearly 40 percent of total Navy energy usage. Because of Category 6.2 funding constraints in FY 1975 and 1976, most NAVSEA synthetic fuels efforts have been performed under Project Number Z0838.

New Energy Sources/New Fuel Sources

Objective

The objective is to develop the necessary technology to make the future fleet less dependent on foreign and domestic petroleum resources by using synthetic fossil fuels. The goal is to determine, through laboratory analyses of the basic properties of syncrudes and synthetic fuels, the suitability of using these fuels in Navy weapons platforms.

Technical Approach

The technical approach generally consists of initial screening of synthetic fuel products through military specification tests and physical and chemical property analyses. On the basis of these screening tests, those fuels which appear to offer significant potential will be continued for small- and full-scale engine testing in Category 6.3 and sea trials in the Category 6.4 development programs. In addition to operational fuel considerations, assay analyses will determine potential sources of other synthetic products (lubricants, hydraulic fluids, etc.) of interest to the Navy.

Aside from synthetic fuels derived from coal, oil shale, and tar sands, fuels derived from other chemical synthesis and conversion processes will also be investigated for potential Navy use.

Laboratory analyses involve conducting:

- DFM military specification tests of synthetic fuel samples. If the results are favorable, candidate fuels will be further characterized by physical and chemical property determinations. If a particular synthetic fuel appears suitable, then it will be recommended for further test and evaluation under the Category 6.3 program. If however the fuel is unsuitable, upgrading studies may be performed so that the manufacturer can be informed of the deficiencies in the product and the additional refinements required before the product can satisfy Navy requirements. Should the fuel show no potential whatsoever, it will be eliminated from consideration.
- Crude assay analyses of various synthetic crudes to determine their potential distillate yield and quality. These analyses are conducted in cooperation with ERDA and other DOD laboratories.

FY 1976/77 Progress

Crude assay analysis, characterization studies, and upgrading investigations on 21 samples (12 synthetic fuels, 3 synthetic crudes, and 6 other synthetic products) have been performed. Of the samples, 6 were derived from tar sands and the remainder from coal and shale oil. The samples were characterized on the basis of fuel specification tests and physical and chemical property analyses. Assay analyses were performed on the synthetic crudes to

determine their potential distillate yields and quality as military fuels. In addition, upgrading studies were conducted on some of the synthetic fuels. The feasibility of using alcohol products as substitute shipboard fuels was investigated.

Planned Milestones (Completion Dates)

The type of studies characterized by the crude assay and other investigations will be continued. Test quantities of DFM from various other synthetic sources will be similarly tested as they become available through ERDA. An optimistic test schedule is projected by the following milestones:

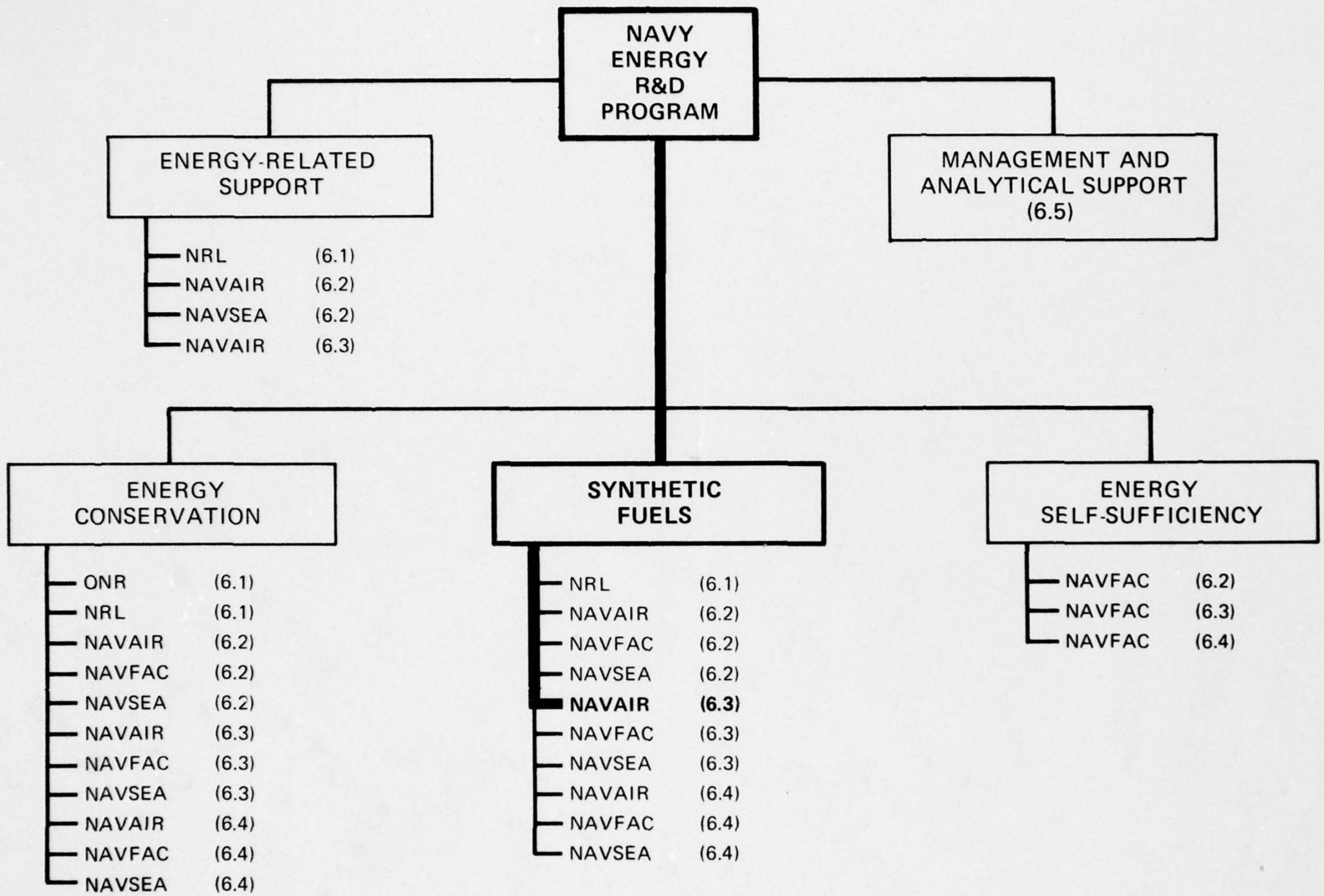
Synthetic Fuel Characterization Studies
- November 1978—Oil shale (Paraho)
- December 1978—Oil shale (second source)
- December 1979—Tar sands (domestic)
- February 1980—Coal liquids

Synthetic Fuel Upgrading Investigations
- March 1976—Tar sands (domestic)
- February 1981—Shale oil
- February 1981—Coal liquids

Crude Assay Analyses
- June 1977—Shale oil
- May 1979—Tar sands (domestic)

January 1981—Technology assessment and by-product investigations.

SYNTHETIC FUELS
ADVANCED DEVELOPMENT (6.3)
NAVAIR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3.6 ADVANCED DEVELOPMENT (6.3)

3.6.1 NAVAIR
Synthetic Fuels
P.E. 63724N
Project Number Z0838

Introduction

Previous program work in synthetic fuels was designated under Project Number SSL50 in FY 1976.

Small-Scale Aircraft Engine Testing With Synthetic Fuels

Objective

The objective is to determine the effects of actual utilization of synthetic JP-5 derived from coal, oil shale, and tar sands. Using small-scale engines and components minimizes the cost of test hardware, test facilities, equipment, and operation and maintenance of test hardware.

Technical Approach

Based on the results of laboratory investigations conducted under the exploratory development program, full-scale engine tests will be conducted on the TF-34 and TF-30 engines using synthetic JP-5 fuel derived from coal, shale oil, and tar sands.

FY 1976/77 Progress

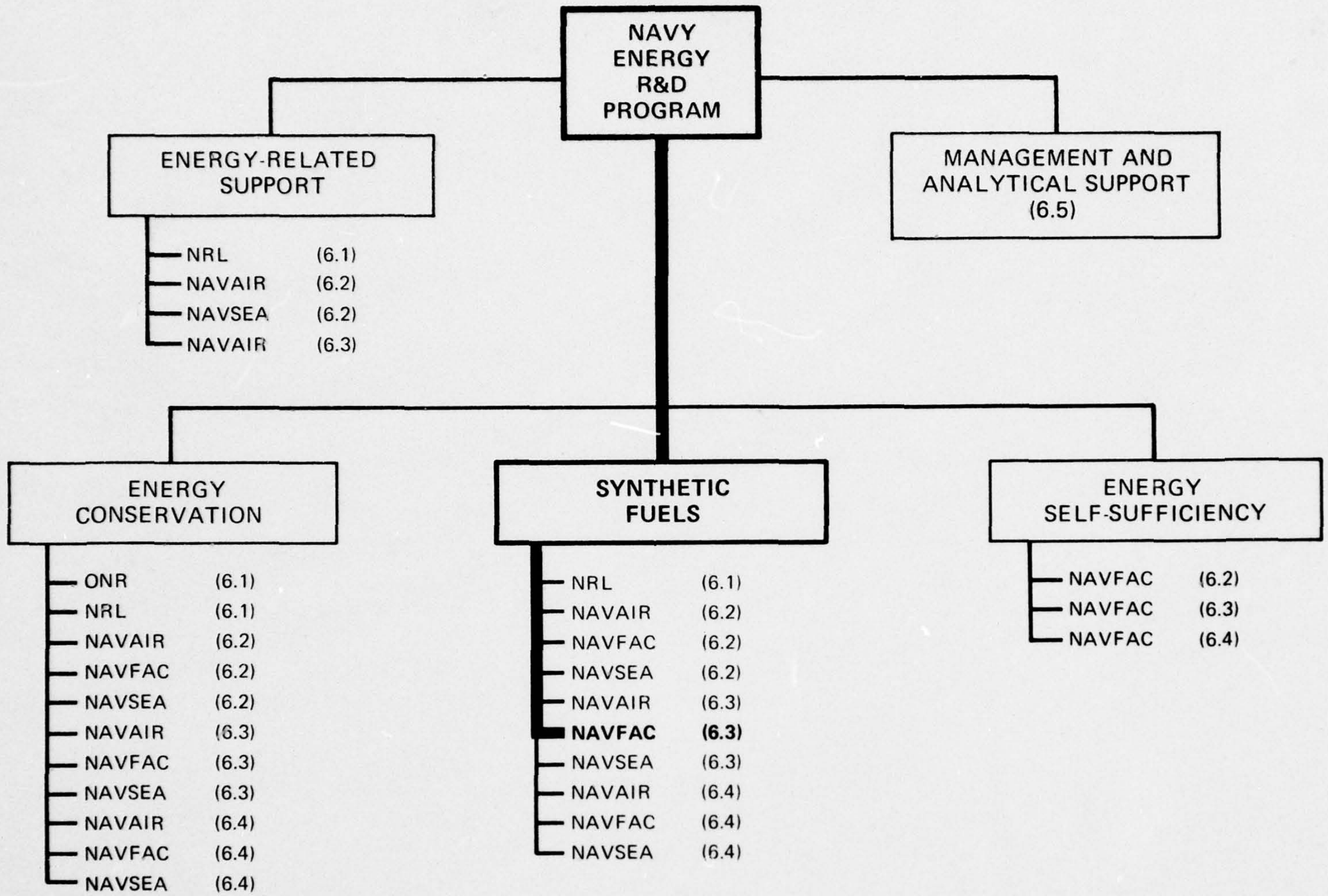
A TF-34 engine test using JP-5 derived from shale oil was run for 30.9 hours. This engine test program was conducted using the general acceptance and qualification tests of MIL-E-5007D, October 1973. Engine performance at sea-level conditions and altitude starting were equivalent to the performance of JP-5 petroleum derived fuel. This project will be held in abeyance in FY 1978 and will resume when synthetic fuels for testing become available.

Planned Milestones (Completion Dates)

August 1980—Conduct preliminary flight rating test on T63, TF34, and TF30 engines using JP-5 from pilot plant synthetic fuel processes.

October 1981—Conduct aircraft ground tests with TF34 engine using JP-5 from demonstration plant synthetic fuel processes.

SYNTHETIC FUELS
ADVANCED DEVELOPMENT (6.3)
NAVFAC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3.6.2 NAVFAC
Synthetic Fuels
P.E. 63724N
Project Number Z0838

Introduction

NAVFAC will suspend advanced development projects in FY 1978 until synthetic fuel from the 100,000 barrel program becomes available.

Coal Utilization Systems—Central Coal Gasification Plant

Objective

The objective is to determine if a central coal gasification plant that would remove sulfur and particulates from the fuel gas is feasible and economical. The production of a clean fuel gas would permit the use of existing oil and gas-fired boilers, as well as existing steam distribution systems. The expected cost of synthetic pipeline quality gas will be determined for use in Navy fuel cost projections.

Technical Approach

A preliminary design, cost estimate, and site selection feasibility study was conducted for a central gasification plant. Two contracts were let for the background work. The first was funded for FY 1976 and FY 197T, and the second for FY 1977. The first contract is for a preliminary design and parametric analysis of two types of coal gasifiers. The second is for a site specific feasibility study to be performed at three or more Navy bases that have been directed to convert to coal. The immediate payback will be to save existing oil through use of gas-fired boilers and steam distribution systems.

FY 1976/77 Progress

The requirements for the plant were determined to be: energy production, 2,500 million Btu per day; coal use, 200 tons per day; and energy in the gas, 185 to 300 Btu per cubic foot.

The contract for preliminary design and parametric analysis was awarded to the Bechtel Corporation, San Francisco, California, and was completed in June 1977.

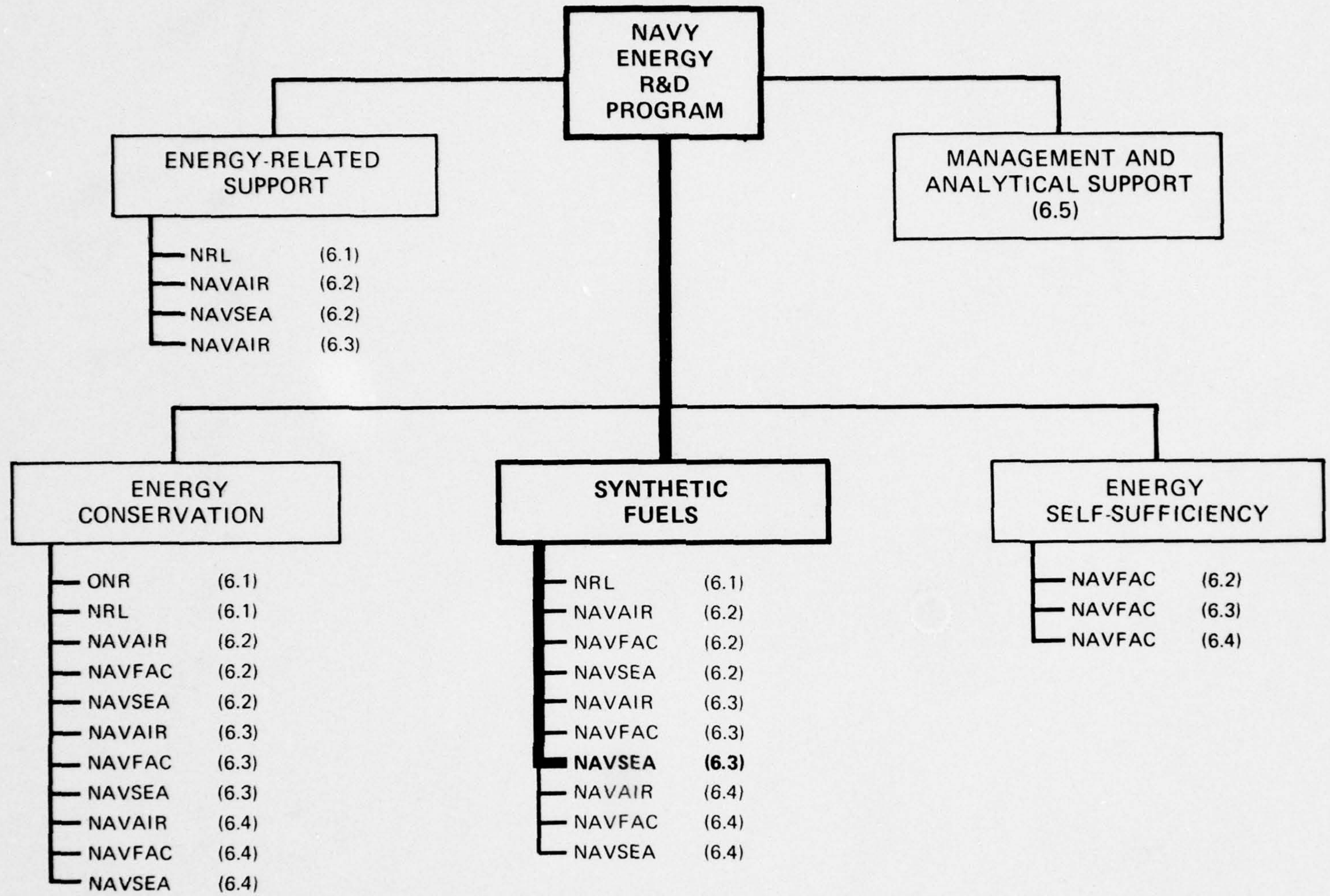
Planned Milestones (Completion Dates)

FY 1978—Issue final report.

SYNTHETIC FUELS

ADVANCED DEVELOPMENT (6.3)

NAVSEA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3.6.3 NAVSEA
Synthetic Fuels
P.E. 63742N
Project Number Z0838

Introduction

In FY 1976, the NAVSEA advanced development effort for synthetic fuels was defined as the light refined liquid fuels for ships project (SSL62). An additional advanced development project was proposed in FY 1976 as the synthetic fuels for ships project (SSLA7) to begin in FY 1977. As a result of recent CNO direction, these two advanced development projects (with the exception of full-scale shipboard testing) were consolidated under one Z-coded designation (Z0838). This task therefore covers research except sea trials of synthetic fuels.

Light Refined Liquid Fuels for Ships

Objective

To support the Navy's general objective of ensuring the continued availability of hydrocarbon fuels for fleet operational use, the objectives of this project are to:

- Assess the suitability of synthetic fuels for shipboard use.
- Assess the feasibility of relaxing and/or modifying current military fuel specifications to increase the availability and decrease the cost of conventional shipboard fuels.
- Assess the suitability of synthetic fuels for shipboard use through small-scale and full-scale engine tests.
- Develop a synthetic fuels, computer-based data bank.

In conjunction with the exploratory development project, the test results from this project will contribute to the overall Navy synthetic fuels goal. In response to the DOD stated objective to modify federal and military fuel specifications to allow greater use of nonpetroleum based fuels, this program will also examine the feasibility of implementing synthetic shipboard fuels in FY 1980 and beyond.

Technical Approach

Subject to the characterization analyses conducted under the exploratory development phase (62765N, SF 57-571-301), candidate fuels will be evaluated in marine boilers, diesels, and gas turbines, and in associated shipboard fuel system components.

This advanced development program will screen candidate synthetic fuels on the basis of their performance in small-scale test rigs. Initial boiler evaluations will be based on tests conducted with a single-burner test rig, and diesel engine evaluations will be based on tests conducted with small-scale (one- and three-cylinder) diesel test engines. Gas-turbine engine evaluations will be based on tests conducted with a single-can combustor (for the DDA501K17) and an annular combustor (for the FT-9 and LM2500) test rigs. If, on the basis of the small-scale engine and laboratory test results, a particular synthetic fuel remains a viable candidate for fleet operational use, it will be recommended for full-scale engine test and evaluation. The tests will use generic engines, representative of the major populations of boilers, diesels, and gas turbines currently used or proposed for use in the fleet.

The compatibility of the candidate fuels with the fuel system components associated with the engine (pumps, filters, injectors, etc.) will be assessed. In addition, laboratory investigations will be directed toward assessing the total impact of synthetic fuels use on the Navy fuel logistic system from supplier to user. Areas of consideration include

logistics and handling requirements, potential fire and safety hazards, and potential personnel health hazards. Personnel health hazards tests will be conducted in cooperation with the Navy Bureau of Medicine and other health-effects agencies.

A computerized data handling system is being developed to support the various synthetic fuels tests and evaluation programs. In addition to providing a centralized system for the storage and retrieval of experimental data for both conventional and synthetic fuels, this system will be designed to support various comparison and correlation studies.

In the area of shipboard fuels flexibility, the feasibility of adopting a multifuel capability will be assessed. Should this assessment indicate that there are measurable cost and availability advantages to be realized by permitting the use of fuels that cannot be procured under current military specifications a determination will be made as to the degree and nature of the fuel flexibility that could be permitted without compromising fleet operational performance.

The final phase of the program will review all test results obtained for a particular synthetic fuel on the basis of which the candidate fuel will be judged acceptable or unacceptable for fleet use. If judged acceptable, fleet implementation guidelines, including necessary revisions to existing military fuel specifications and the establishment of special use oriented requirements, will be developed.

FY 1976/77 Progress

System compatibility and special logistics and handling needs were analyzed, and a semiempirical technique based on shipboard and laboratory measurements was developed to predict shipboard exposure levels of potentially toxic compounds resulting from using synthetic fuels. An investigation of the effectiveness of present fire-fighting agents and techniques in extinguishing synthetic fuel fires was started.

DFM derived from Paraho shale oil was tested in a single-burner boiler, a three-cylinder diesel, and an NTCC-350 six-cylinder diesel engine. Its performance compared favorably with that of standard DFM.

Contracts for gas turbine tests using DFM derived from oil shale were awarded to Detroit Diesel, Allison, Pratt & Whitney; and General Electric. Results are reported in "Compilation of Oil Shale Test Results."

Preliminary results of the fuel flexibility/availability study project indicated that:

- Use of nonspecification conventional fuels may be advantageous under certain conditions, for example, when military specification fuels are not available and nonspecification fuels can be used without compromising safety or performance.
- Shortages of JP-5 have occurred and the situation will be aggravated should the other Services switch from JP-4 to JP-8 and by the introduction of Alaskan crude.
- If the flash point of shipboard fuels were lowered 4° F to 6° F, fuel availability could be increased significantly.

A draft of a computerized system for processing synthetic fuels data was nearly completed. Thus far, the computer storage/retrieval program and initial data correlation program have been completed.

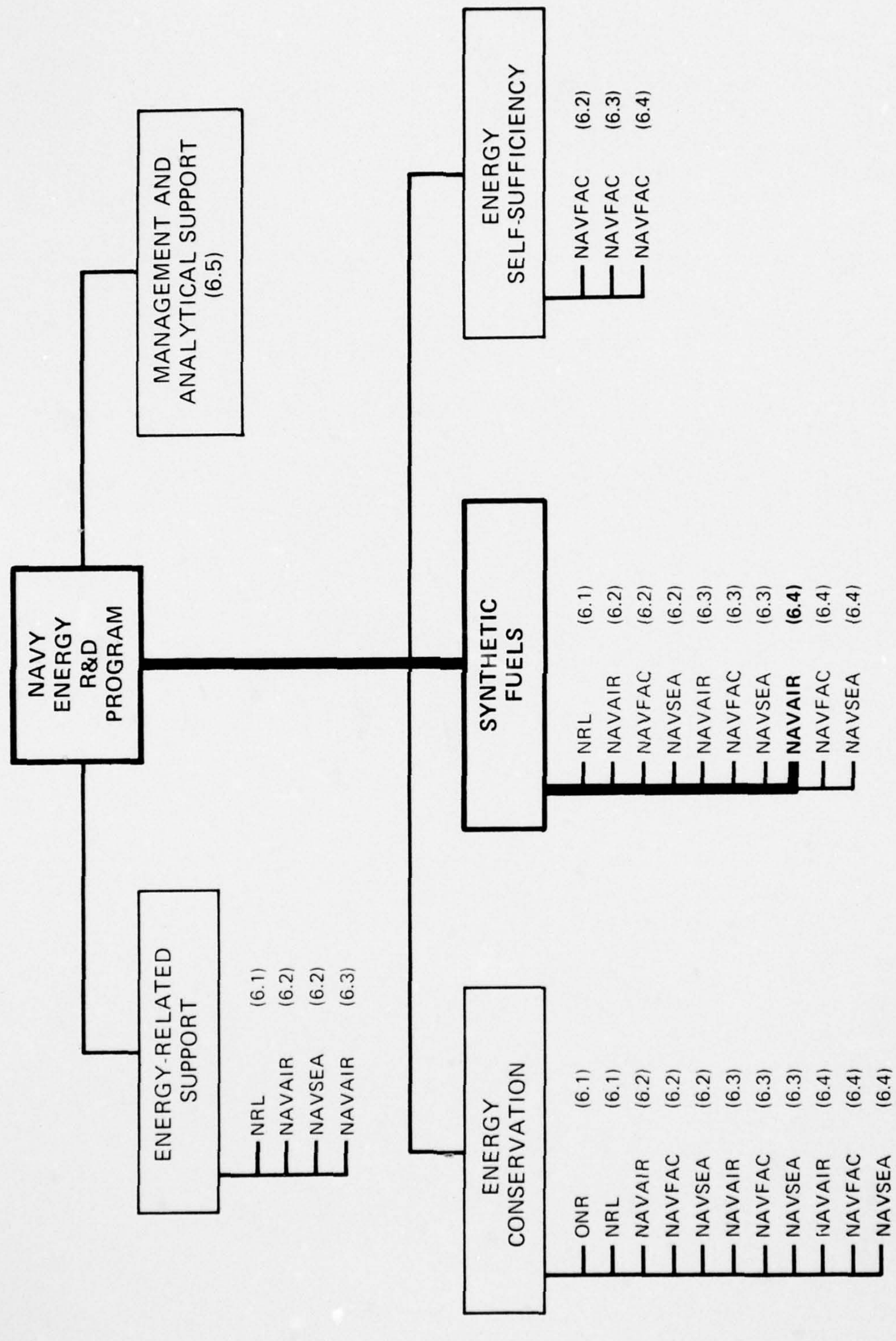
In the ship atmosphere characterization project:

- A 12-point sampling system for monitoring the concentration of fuel vapors in shipboard compartments was developed.
- An in-house evaluation of a thermal desorption unit, portable gas chromatograph, and sorbent media for hydrocarbon vapors was started.
- Atmospheric studies aboard three ships (AO, CVA, FF 1052) were requested.
- Atmospheric studies in the fireroom, engine room, and around auxiliary machinery aboard U.S.S. Hewes (FF 1078) were completed.
- Laboratory chamber studies using petroleum-based DFM and oil-shale based DFM (10,000 barrel experiment) were completed.

Planned Milestones (Completion Dates)

September 1978—Develop fuels qualification procedures.
October 1980—Conduct fuel flexibility studies.
October 1982—Perform data analysis and correlation studies.
Small-scale engine tests
    February 1978—Develop test requirements for 100,000 barrel experiment.
    October 1979—Test with synthetic DFM from first 100,000 barrel experiment.
    October 1980—Test with synthetic DFM from second 100,000 barrel experiment.
    October 1981—Test with synthetic DFM from third 100,000 barrel experiment.
    October 1981—Test with coal liquids.
Full-scale land-based engine tests
    October 1978—Identify test facilities and equipment
    October 1979—Develop test criteria and simulated destroyer power profile.
    April 1980—Conduct test with DFM from first 100,000 barrel experiment.
    April 1981—Conduct test with DFM from second 100,000 barrel experiment.
    April 1982—Conduct test with DFM from third 100,000 barrel experiment.
October 1982—Conduct laboratory analysis (compatibility, logistics and handling, fire and safety hazards, toxicology) of refined fuels.

SYNTHETIC FUELS
ENGINEERING DEVELOPMENT (6.4)
NAVAIR



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3.7 ENGINEERING DEVELOPMENT (6.4)

3.7.1 NAVAIR
P.E. 64710N
Project Number Z0347

Introduction

No previous engineering development work in synthetic fuels has been defined or initiated by any of the SYSCOMs. Because sufficient quantities of synthetic fuels may not be available until FY 1980, no extensive full-scale testing is planned for initiation until then. The availability of refined fuels for extensive full-scale testing from the 100,000 barrel oil-shale experiment will begin in FY 1979. As currently planned, each SYSCOM will have one engineering development work unit.

Sea-Going Flight Tests of Synthetic Fuels in Navy Aircraft

Objective

All full-scale flight testing is currently planned to occur in advanced development; however, extended flight testing may be programmed into engineering development to begin in FY 1979. Flight testing in engineering development should result in synthetically derived fuels qualified for use in Navy aircraft. By FY 1982, synthetic fuels derived from at least one source may become approved for Navy use.

Technical Approach

Full-scale flight testing in advanced development will culminate in final qualification fuels tests. This program would include a test and evaluation of synthetic fuels in fleet operations. Carrier aircraft using synthetically derived fuels in open-sea operations will be tested for maximum performance requirements. The use of synthetic fuels for Navy aircraft under actual sea-going conditions will be evaluated as a consequence of this program. Actual handling and safety aspects of the synthetic fuels will be tested at sea.

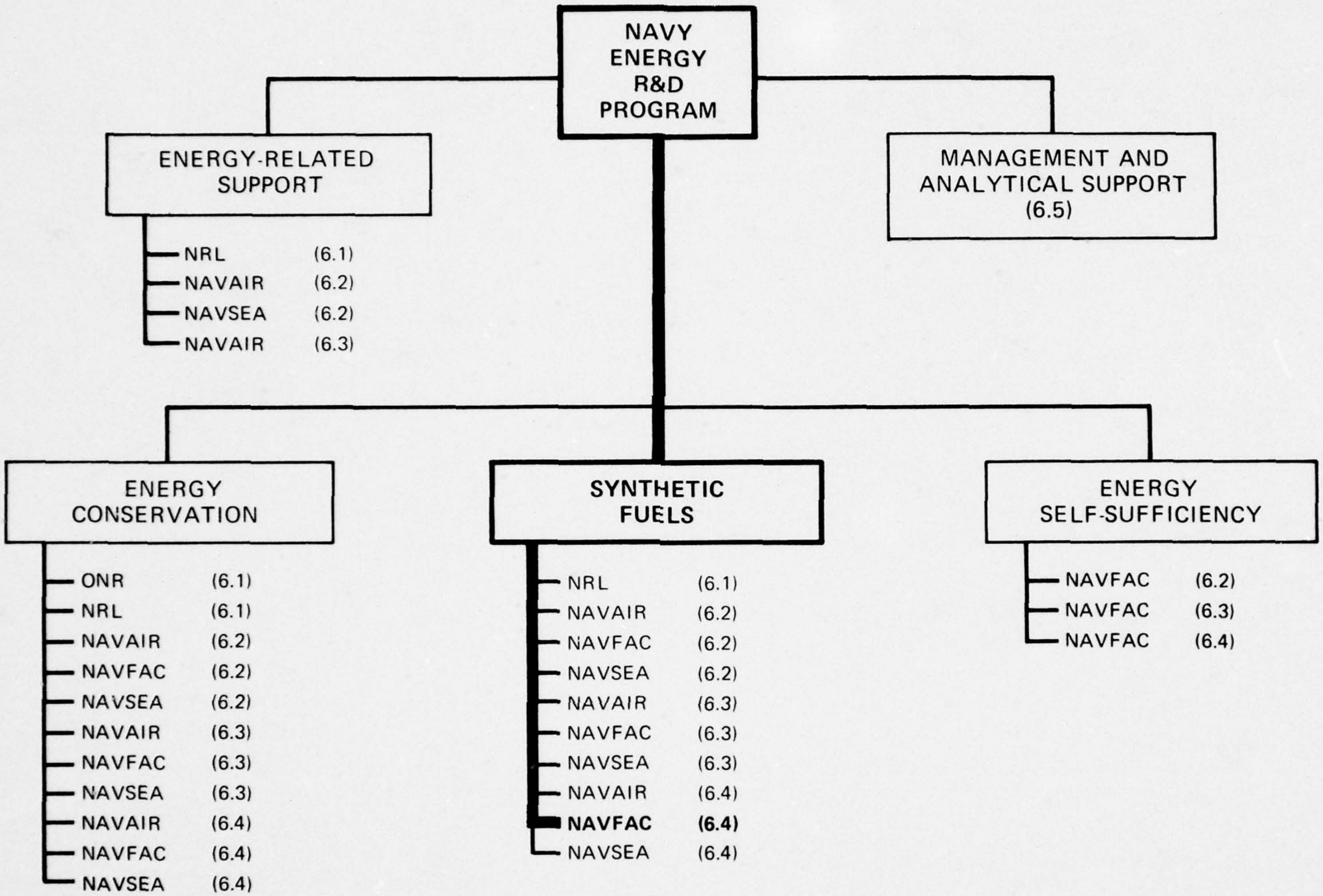
FY 1976/77 Progress

This project will begin in FY 1979. The program has precedence over other programs, except for some full-scale testing in advanced development.

Planned Milestones (Completion Dates)

April 1980—Develop detailed final qualification test plan.
July 1980—Coordinate test and evaluation program with OPNAV.
October 1981—Conduct sea-going flight tests with JP-5 from pilot plant synthetic fuel processes.
October 1982—Conduct sea-going flight tests with JP-5 from demonstration plant synthetic fuel processes.

SYNTHETIC FUELS
ENGINEERING DEVELOPMENT (6.4)
NAVFAC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Endurance Testing of Synthetic Fuels in Shoreside Systems

Objective

The objective is to determine the suitability of using synthetic fuels in shore-based facilities for extended time periods under normal operational conditions. Included is the determination of implementation and operational requirements.

Technical Approach

Synthetic fuels testing from the Category 6.3 to the Category 6.4 level will be dependent on both Category 6.3 test results and the availability of sufficiently large quantities of the appropriate fuel. By the time Category 6.4 testing is complete for a particular fuel, scheduling of commercial production of the fuels should have been determined. The test facilities established under the advanced development full-scale test program will be used for this test program.

Fuels successfully fired in short duration tests will be burned in full-scale systems for longer periods, about 1,000 hours. Problems not anticipated during short-term testing in the Category 6.3 program will be evaluated to develop full-scale operational procedures and specifications necessary for special handling equipment, pollution control equipment, and safety procedures.

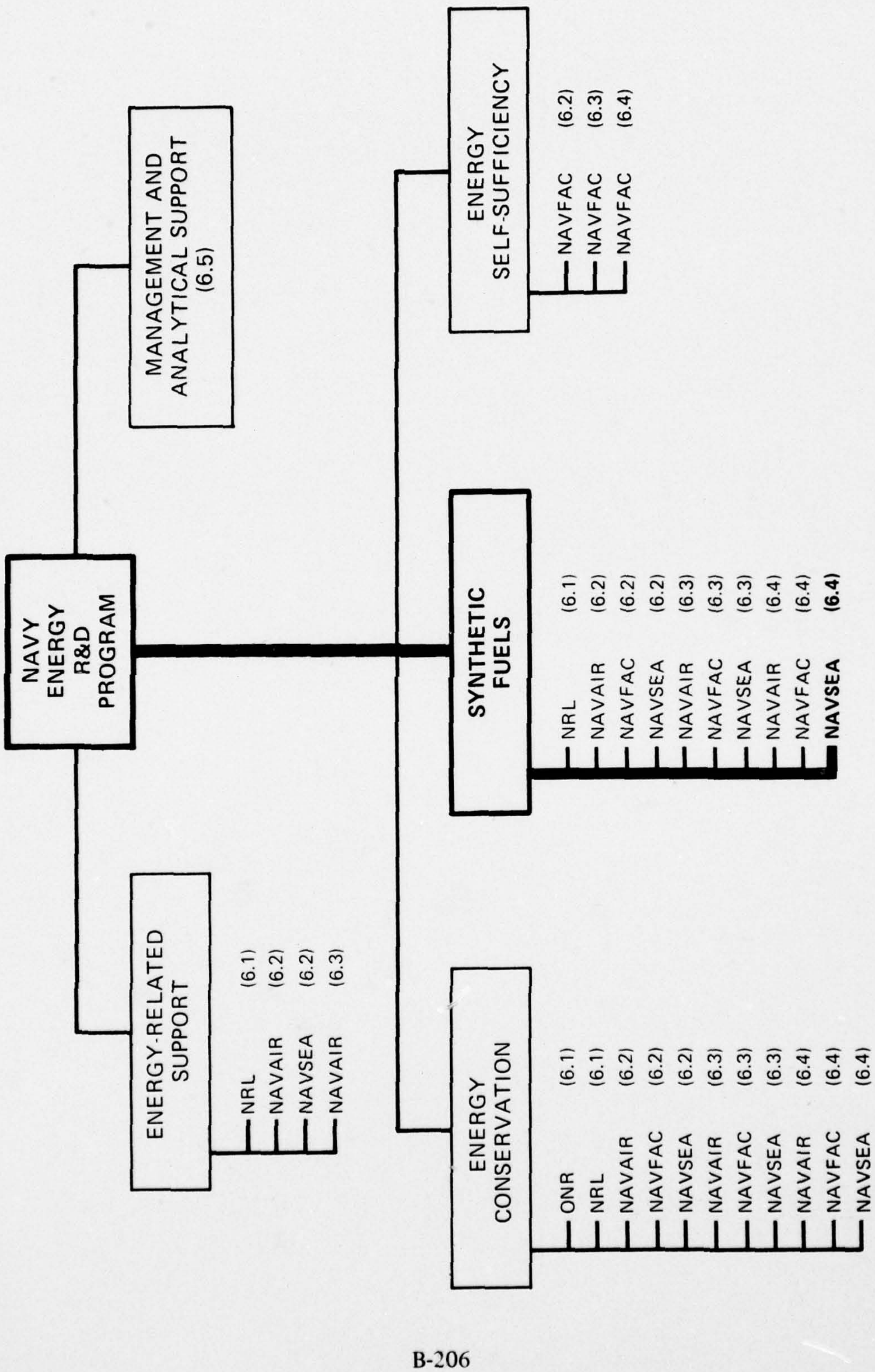
FY 1976/77 Progress

This project will begin in FY 1980 when significant quantities of synthetic fuels should be available.

Planned Milestones (Completion Dates)

January 1980—Develop a detailed endurance test plan.
October 1980—Conduct endurance tests of fuels from first 100,000 barrel experiment.

SYNTHETIC FUELS
ENGINEERING DEVELOPMENT (6.4)
NAVSEA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Sea Trials of Synthetic Fuels for Navy Ships

Objective

The objective is to perform synthetic fuel tests in the land-based full-scale test program; the availability of test fuels will lead to sea trials in FY 1978. This is a new interim effort for FY 1979. The sea trials will lead to final qualification of synthetic fuels for Navy ships.

Technical Approach

The eventual acceptance of synthetic fuels for fleetwide use is dependent on satisfactory completion of the sea trials and review phases. Initial sea trials will be 1 week in duration and identify special handling problems and train personnel. Later long-term sea trials, not to exceed 6 months in duration, will be conducted to assess the long-term effects of synthetic fuels use in an operational environment.

FY 1976/77 Progress

This project will begin in FY 1979.

Planned Milestones (Completion Dates)

October 1978 to January 1979—Develop a synthetic DFM qualification test plan based on full-scale test program experience.

January 1980 to October 1981—Conduct sea trials of DFM from second-generation processes.

January 1982 to October 1982—Conduct sea trials of DFM from third-generation processes.

SYNTHETIC FUELS DOCUMENTATION

3.8 DOCUMENTATION

NAVSEA (Contact: C. Krolick—301-267-2674)

"Model 501-K17 Gas Turbine Single Burner Evaluation of Shale Derived DFM," EDR 8660, January 1976.

"Main Propulsion Boiler Evaluation of Synthetic Fuels," NAVSEC B-1183, October 1975.

"Evaluation of the Performance of Liquid Synthetic Fuels in an FT-9 Combustion Chamber," FR-7286, June 1976.

"Navy Fuels Comparison," Cummins Diesel Report 2282, September 1975.

"NAVSEC PHILADIV Diesel Engine Test Results Using Synthetic Fuels," June 1976.

"Development of Acceptance Criteria for Synthetic Marine Fuels," Battelle, March 1976.

NAVFAC (Contact: W. Adams—703-325-8535)

"Residual Shale Oil Burning Tests," M-63-76-13, T. T. Fu and B. E. Swaiden, September 1976.

"Fuel Cost Escalation Study," NWC-TM-2950, E. E. Kappelman, S. M. Lee, R. F. Klever, and D. R. Cruise, NWC, China Lake, November 1976.

"Use of Synthetic, Waste, and Substitute Fuels," 63-75-12, T. T. Fu, December 1974.

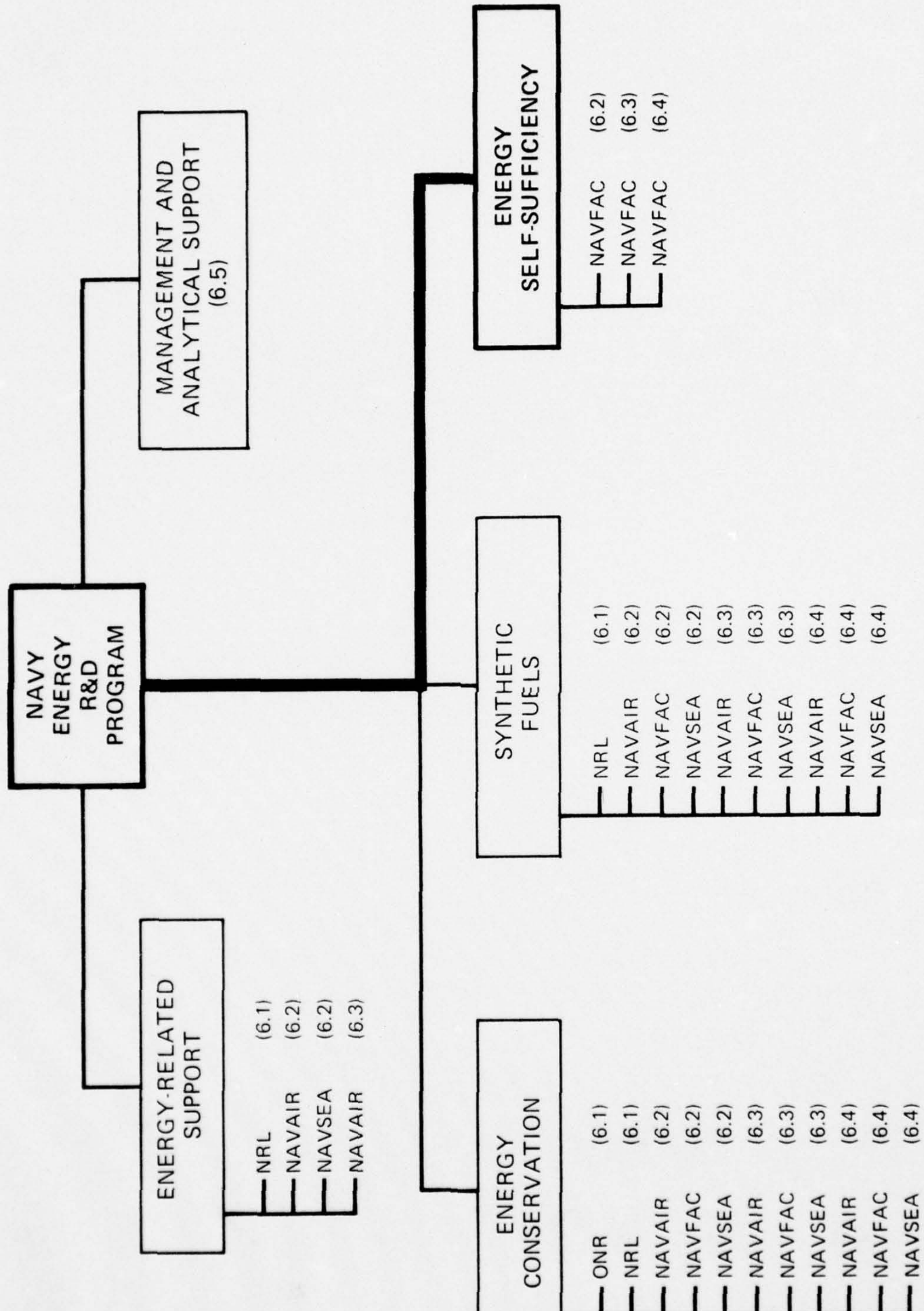
"Summary of Available Information on Synthetic Lubricants," 64-75-04, C. W. Anderson, December 1974.

"Use of Synthetic and Waste Fuels," 63-75-15, T. T. Fu, January 1975.

"JP-5 for Dry-Sump Diesels," 63-75-17, B. E. Swaiden, February 1975.

"Use of Synthetic, Waste, and Substitute Fuels," 63-76-2, T. T. Fu and E. E. Cooper, July 1975.

ENERGY SELF-SUFFICIENCY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MANAGEMENT AND ANALYTICAL SUPPORT (6.5)

4.0 ENERGY SELF-SUFFICIENCY

4.1 INTRODUCTION

The technical objective of the energy self-sufficiency strategy is to demonstrate technical feasibility and collect cost and performance data for hardware and systems that will reduce dependence on liquid hydrocarbons and promote use of renewable energy sources.

Development and application of energy self-sufficiency technologies will provide several broad benefits:

- Decreased dependence on petroleum supplies, especially at remote locations where supply lines are more susceptible to interruption and involve greater transport costs.
- Mechanisms for keeping abreast of nationwide development of energy technologies, such as solar conversion systems, that both civilian and military sectors may apply at a rapidly accelerating rate in the future.
- Application of systems and tapping of resources that may result in less adverse environmental effects than those caused by conventional sources and systems.
- Contribution of user experience and operational data to the civilian sector.

The Navy Energy Program Office at CEL, Port Hueneme, California, will conduct investigations (both in-house and by contract) and transfer the technology to NAVFAC and field activities. NWC, China Lake, will provide extensive support in geothermal, wind, and solar research activities.

All efforts in the self-sufficiency R&D strategy will take into consideration related Army and Air Force projects, and will closely monitor ongoing R&D effort in the civilian sector, particularly those conducted by ERDA, EPA, and EPRI. Systems available through ERDA and industry will be used for application studies whenever feasible.

Solar, wind, geothermal, and waste recovery technologies have been selected for investigation since the energy sources themselves often originate at the use site. Because aggressive R&D programs exist in the civilian sector, they can provide hardware and concepts from which the Navy can benefit with a minimum level of effort. Also, weather conditions vary from location to location so that solar, wind, and other weather-dependent sources must all be considered to take full advantage of local sources. A brief description of the considerations involved in selecting each major area of the self-sufficiency projects follows.

4.1.1 Solar

Solar technology investigations will focus on demonstrating equipment that is becoming more available to the Navy as the national interest in solar energy increases. Technical guidance to select solar system equipment and to evaluate the operational and economic practicality of a candidate system at any given site is needed to ensure cost-effectiveness and reliability. It should be based on careful analysis of the fundamental power requirements, equipment costs, climatological conditions, and test data.

Concentration in the near term will be on solar heating and cooling systems since equipment for this application is available commercially and the technology is much more advanced than for some other solar applications. It is estimated that about 10 percent of Navy facilities could be economically supplied with solar energy in the near future, with annual savings of up to $6 million on the fuel bill.

Desalination plants are currently in operation in many naval facilities and some of them are in areas where sea water and sunshine are both available in large amounts. In these areas, application of solar-powered stills could replace or reduce the need for oil or other fuels used in existing flash-type or other desalination units. For moderate capacity facilities, especially at isolated bases, water produced by solar desalination may be less expensive than conventionally produced water.

Power generated from solar-to-electric systems could displace electric power purchased from the utility industry at competitive rates. As with other on-site available sources, solar-to-electric power is desirable from a logistic point of view, especially at remote locations. ERDA is looking at several concepts primarily in the 100 to 500 Mwe range; the Navy will both monitor the ERDA efforts as well as address specific Navy problems, such as scaling down, as the technology develops. Particular attention will be given to arrays of small modular generating units, which could produce economic power when and if such units are manufactured in mass quantities.

4.1.2 Wind

A substantial number of locations in the Navy shore establishment have average annual wind speeds sufficiently high for wind generators to produce electrical power competitive with conventional power plants.

Although the economic payback periods are 10 to 20 years, wind generators may be able to supply 3 percent of the total shore facility energy demand and eventually save the same percentage in utility costs. If energy storage is used, wind power generation could replace conventional plants and save fuel, assuming that the additional capital for the storage system is justified. Further R&D is required to determine the cost-effectiveness of using energy storage systems with wind power systems. Wind power is also a relatively pollution-free, inexhaustible source of energy.

Small wind generators are commercially available and large units (100 to 1,500 kw) are being developed by ERDA contractors. Although ERDA has a test program for

generators up to 15 kw, emphasis is on assessing their feasibility for rural agricultural use. Thus the Navy will conduct a limited number of tests to determine feasibilities for use at Navy installations and to develop compatible power conditioning systems, if necessary.

4.1.3 Geothermal

A number of Navy bases are situated on or near geothermal deposits. At more remote sites, such as the Navy facilities at Adak and Hawaii, fossil fuels must be imported to generate electricity and heat living/working quarters. Where available, geothermal energy can provide these needs at substantial savings. For instance, approximately 4.1 million gallons of JP-5 jet fuel are used at Adak each year to generate electrical power, and another 3.1 million gallons are used to heat facilities. Use of geothermal energy at Adak could result in yearly savings up to $4 million at present fuel costs with further savings under projected price escalations.

In addition, geothermal resources could be used to produce fresh water, either through conversion of sea water or by processing geothermal fluids directly. Geothermal resources also provide an energy source that is not normally subject to variations with time of day or weather conditions and does not require the added complexity of a storage system.

A limited number of sites exist in the continental United States with geothermal resources that, though not remote, appear sufficiently important to be considered a national energy asset. One is the Coso Thermal Area, where all the near-surface activity lies within NWC. Experts on geothermal deposits have predicted capacities as high as 4,000 Mw for the area. It is important that the Navy examine these resources and develop their potential for the benefit of the Navy in particular and the United States in general.

4.1.4 Waste Recovery

Deriving energy from solid waste at Navy installations contributes to conservation of fossil fuels at the same time it uses materials which otherwise must be disposed at added expense. If only 70 percent of the Navy's annual generation of solid waste (25 million cubic yards) were converted to steam, over 4×10^6 million Btu of fuel oil would be saved a year.

Packaged heat recovery incinerators, combined liquid and solid waste processes, and burning solid refuse-derived fuel (RDF) in conventional boilers are the options available for the Navy to recover energy from solid waste.

Packaged heat recovery incinerators have been analyzed. The results indicate that payback periods of less than 10 years can be expected, including operating costs, capital investment, and an allowance for decreased disposal cost. Economic and operating analyses of combined liquid and solid waste processes and RDF burning are now under way at CEL.

Combined liquid and solid waste processes can make a significant contribution to the energy self-sufficiency of Navy bases. Closed-cycle processes would be applicable where air pollution control is prohibitive for conventional incineration.

Densified RDF has the potential of being an excellent material for waste energy recovery processes. Compared with other forms of RDF, densified RDF has significantly lower storage costs/Btu, and is particularly amenable to fully automated storage and handling. If refuse were densified at generating sources, a reduction of more than 65 percent of the energy and manpower required to collect and transport the waste is possible. This benefit is expected to more than offset the costs of the densification processing.

4.1.5 Application and Data Analysis Studies and Demonstration

Approximately 35 percent of the Navy's total energy bill goes to heat and cool Navy buildings and, despite conservation measures, the cost is still rising. Other projects in the self-sufficiency program are primarily geared to demonstrating technologies that economically collect and/or harness renewable forms of energy such as solar, wind, and geothermal. Development work is also needed to apply these sources to environmental building control systems. HVAC systems using solar and wind energy sources will satisfy these requirements. Demonstration of such systems will provide technical guidelines for Navy-wide use.

Alternative energy sources such as wind and solar are often available at a given location only intermittently. Thus, storage systems are necessary to maintain a continuous, dependable supply of energy. R&D is required to develop or improve storage systems that can be integrated with the overall system for production of either electrical power or space heating and cooling.

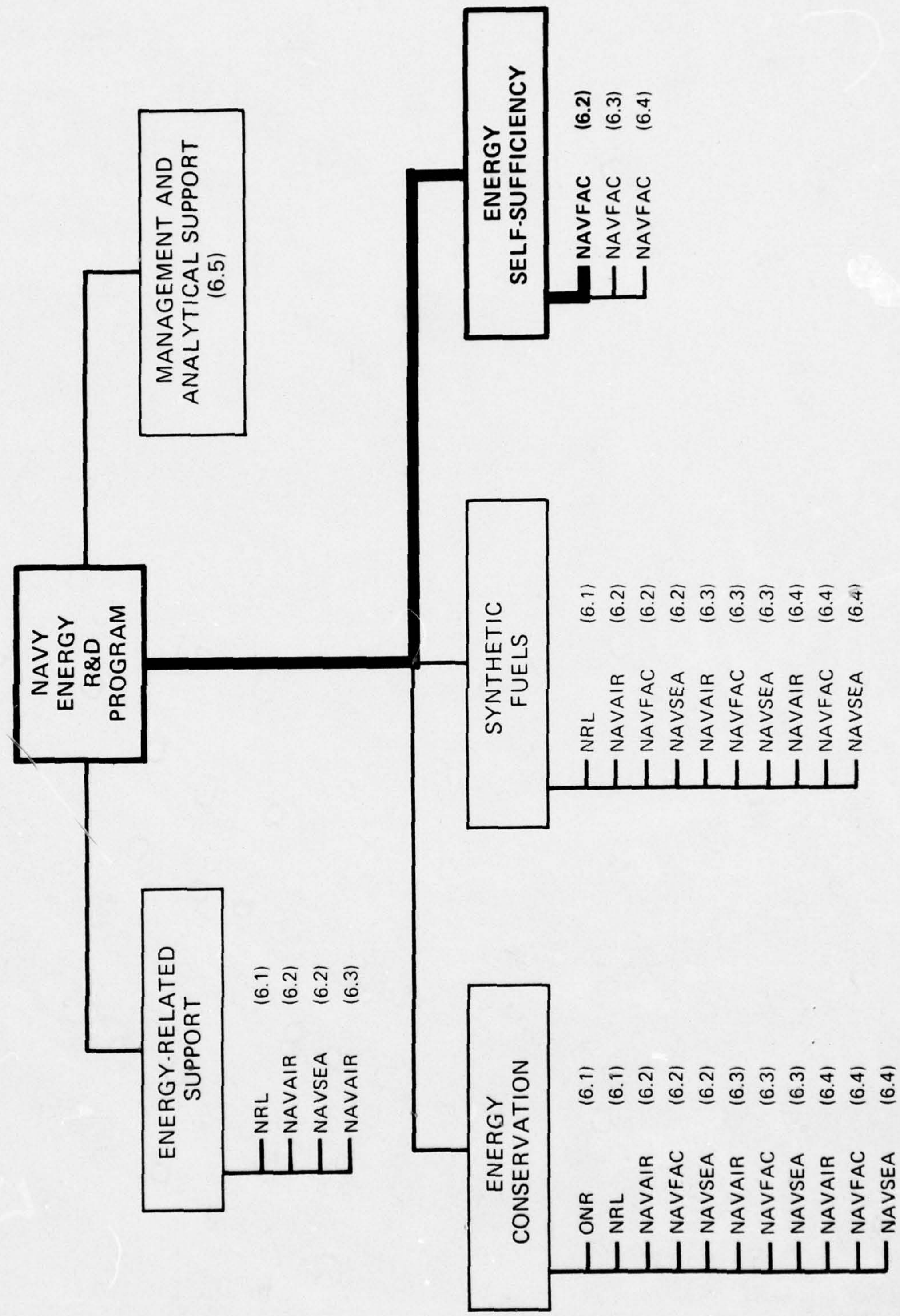
Before a site can be selected for development of an alternative energy source and before a power system can be designed and optimized for a specific site, a considerable volume of site characteristics data must be available. Thus, a centralized data compilation of site characteristics is required and will include solar radiation intensity, meteorological data, waste material quantity and composition, and geological data for Navy sites.

4.1.6 Coal Utilization Technology

The Navy has been asked to burn coal in increasing quantities to reduce dependence on petroleum fuels. Currently, coal costs less than oil, and some individuals are inclined to project lower escalation in the price of coal compared with other fuels. Further, coal may be more readily available in some locations than petroleum. If severe petroleum allocations are imposed in the future, the use of coal for shore facilities would allow additional petroleum fuels for ships and aircraft.

New coal technologies, such as fluidized-bed boilers, will be monitored to consider systems that could replace the use of coal for petroleum supplies.

ENERGY SELF-SUFFICIENCY
EXPLORATORY DEVELOPMENT (6.2)
NAVFAC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4.2 EXPLORATORY DEVELOPMENT (6.2)

4.2.1 NAVFAC
Shore Facilities Energy Self-Sufficiency
P.E. 62765

Introduction

Exploratory development efforts in energy self-sufficiency will guide necessary selection and demonstration of advanced energy collection and conversion systems for Navy use. Studies will include determining cost-effectiveness, conducting preliminary test and evaluation of existing equipment, monitoring other government and industrial efforts, determining specific applicability to naval installations, and selecting a site. While currently available hardware and systems will be studied wherever possible, some effort may be needed for preliminary design of modified systems for certain technologies. (For example, if the available system were designed for larger-scale applications than normally required at Navy facilities, design will be required.) Performance and cost data collected in these tasks may lead to: (1) recommendation for full-scale demonstration of a modified system under advanced engineering development required for unique naval facilities and equipment, and (2) collection of data necessary to make minor adjustments in currently available systems for immediate application at shore facilities.

Frequently, data needed for site selection and testing of existing hardware and equipment (specific facility power requirements, waste material production, end-use data) will be similar to that being collected and analyzed under exploratory development projects in the conservation area. Duplication of effort will be avoided.

Solar Projects for the Advanced Energy Utilization Test Bed (AEUTB)

Objective

The objective is to test and evaluate solar collector and storage method systems and integrate them with advanced HVAC systems and building designs.

Technical Approach

An advanced energy utilization test bed (AEUTB) was constructed as part of the building design and energy analysis task. This will serve as a flexible test bed for full-scale solar collectors, storage techniques, solar stills, and solar dryers operating as a system integrated with advanced HVAC systems and building designs. Solar collectors, storage, and other component concepts showing promise will be analyzed and tested separately by contract, particularly when test data is not available or when a concept's potential has been fully identified. Component tests may precede application on the AEUTB or a general recommendation for naval usage.

FY 1976/77 Progress

The overall design of the solar collectors and storage system for the AEUTB has been completed. Six solar collectors have been procured from Sunpower, AMSUN, PPG, Champerlin (NBS), Northrup, and Sunburst. Other collectors may be purchased in the future. The collectors are being evaluated on the AEUTB test stand. NBS tests for the PPG collector have been completed.

Planned Milestones (Completion Dates)

December 1977–Test first phase solar system installed on the AEUTB.
January 1978–Submit technical memorandum on first phase results.
August 1978–Test systems on test stand as necessary prior to AEUTB installation.
August 1978–Modify and continue tests on solar collector and storage system as necessary.
August 1978–Modify and test solar collector and storage system with solar.
September 1978–Prepare technical note on work to date (estimated publication date–March 1979).
September 1979–Test collector and storage systems adapted to advanced heat absorption air conditioning units and submit technical memorandum.
September 1980–Evaluate long-term storage units and submit technical memorandum.
Continuing–Conduct test and evaluation on promising advanced solar systems.

Solar Heating and Cooling Design Guide

Objective

The objective is to provide technical guidance to evaluate a given solar system at a selected site and to select or design equipment for the system.

Technical Approach

Technical guidance to evaluate a given solar system at a preselected site and to select or design equipment for the systems are presented in a solar design guide. This report is applicable to all types of Navy buildings and will be periodically revised and expanded to include cooling advancements, placing more emphasis on equipment and HVAC aspects of the total system.

FY 1976/77 Progress

The solar design manual has been completed and distributed. Data are being collected on collector types and efficiencies, as well as on insolation levels at Navy CONUS sites. A computer simulation program, TRNSYS, for solar systems has been made operational. The contractor has developed several computer simulations that are useful in performing system analysis and collector sizing.

Planned Milestones (Completion Dates)

Continuing—Revise and update guide for solar heating and cooling of buildings.
Continuing—Maintain data set on collector efficiencies.
Continuing—Collect information on ERDA and other solar programs for applicability to guide.
January 1978—Compare design guide predictions with AEUTB performance.
May 1978—Compare design predictions with computer simulations of AEUTB and selected Navy locations.
September 1978—Revise guide on heating and include analytical methods of cooling buildings.

Preliminary Assessment of Photovoltaic Equipment for Advanced Bases

Objective

The objective is to make a preliminary assessment of the applicability of photovoltaic systems at Navy advanced bases.

Technical Approach

The cost and performance of currently available photovoltaic systems will be continually monitored and evaluated for applicability at Navy advanced bases. Limited tests will be made. A CEL report, updated annually, will document findings and present recommendations. Recommendations will be made for demonstration of a full-scale system in the engineering program.

FY 1976/77 Progress

Collection of a bibliography of photovoltaic equipment is being conducted as a continual process. A search for possible uses of photovoltaic energy for remote Navy facilities has been completed, possibly applying a large collapsible photovoltaic collector for use with containerized photovoltaic/battery power supply system. However, the collapsible collector concept was judged infeasible due to the wind loads it would encounter.

Planned Milestones (Completion Dates)

Continuing–Maintain bibliography on photovoltaic systems.
September 1979–Conduct feasibility studies and tests of photovoltaic devices for contingency situations.
September 1979–Submit technical memorandum on studies to date.

Self-Sufficiency
Category 6.2
NAVFAC

Feasibility of Solar Desalination Applications at Navy Sites

Objective

The objective is to determine the feasibility, cost-effectiveness, and performance of solar desalination methods applied at Navy sites.

Technical Approach

A study will be conducted to determine which desalination methods can be economically powered with solar energy. A study will also be conducted to determine which Navy base is most suitable for a solar desalination plant. A systems study will then be performed to determine the best method to be used at the selected Navy installation.

FY 1976/77 Progress

The literature and state-of-the-art review on solar desalination has been completed, as well as a survey of the Navy's fresh water needs. FY 1977 progress also included an economic study, computer optimization analysis, bench-scale experiments of several solar desalination concepts, analysis of a single- and multiple-effects hemispherical solar still, and a computer optimization study on a high-performance solar still.

Planned Milestones (Completion Dates)

June 1978—Perform laboratory experiments on bench models for solar desalination and issue a technical memorandum.

February 1979—Prepare contract schedule to implement design of a full-scale system (estimated award date is May 1979).

Advanced HVAC Systems Studies—Solar Augmented Heat Pumps (SAHP)

Objective

The objective is to investigate and develop concepts of solar/night radiation heat pumps to reduce energy use and level loads in Navy buildings.

Technical Approach

Problems and benefits associated with retrofitting existing buildings with SAHP systems will be evaluated. Costs and potential energy savings will be considered.

FY 1976/77 Progress

Current literature is being organized for preparation of a technical memorandum. Computer simulations of alternative designs are in progress.

Planned Milestones (Completion Dates)

March 1978—Investigate the problems and benefits associated with retrofitting buildings with SAHP and prepare technical memorandum.
September 1980—Experiment with wind-powered heat pump systems at the AEUTB.
March 1982—Demonstrate the design principles of efficient operation of air conditioning systems at part load in new and existing applications.
April 1982—Demonstrate retrofit SAHP.
September 1982—Organize and perform joint ERDA/Navy tests and demonstrations of advanced SAHP systems.

Energy Storage Techniques

Objective

NAVFAC is defining Navy requirements for storage systems integrated with use of local energy sources.

Technical Approach

A variety of storage methods will be evaluated to identify which systems could be integrated with solar and wind energy systems at remote bases based on technical and economic feasibilities.

A contract to provide a comparative storage methods study will be awarded in FY 1978. Studies on specific methods will include thermal stratification, dissolved salts storage, and other chemical storage methods. Bench-scale experiments may be initiated for systems showing potential. Efforts will be coordinated with ERDA storage R&D activities.

FY 1976/77 Progress

Colorado State University was selected to study thermal stratification in water tanks. Flow visualization experiments on thermal stratification have been initiated in a larger tank. Work schedules have been prepared for the storage and dissolved salt storage contracts.

Planned Milestones (Completion Dates)

October 1977—Prepare schedule for contract to study and compare storage methods (estimated award date is December 1977).
January 1978—Monitor contract for dissolved salt storage study.
July 1978—Monitor contract on comparative storage methods study (contractor's report is due July 1978).
September 1978—Issue technical memorandum to sponsor covering FY 1978 efforts.
September 1978—Define Navy needs for dissolved salt energy storage at remote bases.

Advanced Power Cycles for Advanced Bases

Objective

The objective is to investigate the feasibility of using alternative fuels at Navy advanced bases, and evaluate and recommend system changes that reduce the logistical problems of petroleum fuels.

Technical Approach

Systems will be developed for using solar energy for the production and use of synthetic fuels to generate electrical power at remote Navy and Marine bases. The choice of systems will be based on scenario assessments of the overall energy sequence (transport, storage, conversion, utilization) at remote or advanced bases. Hydrogen production through thermochemical and electrolytic processes will be investigated. The performance and relative advantages of engines and burners operating on synthesized fuels (hydrogen, ammonia, and methane) will be selected for remote or advanced base applications.

FY 1976/77 Progress

An experimental facility to study combustion of hydrogen, ammonia, and methanol was set up. Literature on thermochemical hydrogen generation and on the performance of synthetic fuels in internal-combustion engines was reviewed, and energy requirements for advanced bases were estimated. A technical memorandum on hydrogen generation processes was issued.

This project is unfunded in FY 1978.

Planned Milestones (Completion Dates)

January 1979—Prepare preliminary design for a bench experiment of a dissolved salt storage system and chemical storage system.

September 1979—Perform laboratory experiments on bench model of a dissolved salt storage system and issue technical memorandum to sponsor.

September 1979—Define Navy needs for chemical storage of thermal energy at remote bases.

September 1979—Perform laboratory experiments on bench model of a chemical storage system and issue technical memorandum to sponsor.

Alternative HVAC Systems Study

Objective

Several advanced air conditioning systems that can operate efficiently at part load are to be evaluated for possible application to Navy facilities. The present work is directed toward economic evaluations and comparisons of solar air conditioning systems. Another area of pursuit involves the problems and benefits associated with retrofitting existing buildings with solar augmented heat pumps.

Technical Approach

This project is directed at identifying and comparing existing absorption air conditioning systems with those under development. This will include research efforts in private industry, universities, and ERDA. The concept of retrofitting existing buildings with solar augmented heat pumps will also be investigated as part of the alternative HVAC system concept. These systems will be evaluated in terms of their economic and thermodynamic feasibility, compared with other systems that can be used to air condition Navy buildings.

FY 1976/77 Progress

A study of the potential of solar air conditioning was completed, and a contract for evaluation of ammonia-sodium thiocyanate solar absorption systems has been awarded.

Planned Milestones (Completion Dates)

Continuing—Investigate state-of-the-art advances and HVAC research needs to maintain a technical base and develop program plans.

September 1978—Investigate air conditioning systems for efficient operation at part load. Perform life-cycle cost analyses and determine economic potential.

February 1979—Investigate the problems of retrofitting existing air conditioning systems to employ the design principles identified in the earlier work on efficient operation of air conditioning systems at part load.

March 1979—Perform simulation and life-cycle cost analysis of wind powered heat pump.

September 1979—Investigate applications and economics of solar regenerated dessicant dehumidification.

September 1980—Investigate applications and economics of passive HVAC systems.

September 1981—Investigate the concepts of solar reheat and a condenser efficiency monitor.

Evaluation of 5- to 10-kw Capacity Wind Generators to Supply Power for Buildings

Objective

The objective is to develop methods and hardware to convert the output of small-capacity wind machines to either heat for environmental control of buildings or to 60-Hz constant-voltage electricity.

Technical Approach

The methods and hardware to use the electrical output of small-capacity commercial wind generators efficiently will be developed by using a 5-kw capacity, horizontal axis, 3-bladed, propeller-driven 3-phase AC generator.

The operational data on the wind generator's performance for space heating applications will be collected through extensive field testing at Laguna Peak or San Nicholas Island. Automatic data recording equipment will be used to collect the field data for convenient analysis on a digital computer. Methods and hardware developed during the wind power research at the AEUTB will be used to support a 4-year program to demonstrate a 10-kw wind generator in the engineering development program. A site will be selected based on results of NWC surveys and economic analysis.

FY 1976/77 Progress

The 5-kw wind generator with a load-switching system was installed and tested at Laguna Peak, California, during FY 1976. The generator's output was dissipated into resistive loads comprising heaters and light bulbs. An automatic data logger recorded the line voltage, load current, line frequency, and instantaneous power output in a digital format at 30-minute intervals. The data were analyzed to determine the output curve for the 5-kw wind generator. The estimates indicate that the site has an annual average wind speed of 10 miles per hour, and the generator would produce 7,200 kw per hour annually.

The generator was rebuilt after a propeller failed in November 1976 because of a faulty weld. The rebuilt test setup is operating well. The power conditioning equipment has also been redesigned and consists of an automatic load matching device with a variable transformer. Tests on the 5-kw generator are encouraging.

An economic analysis was done comparing the cost of wind energy to that of present systems at 11 sites recommended for future demonstrations by NWC, China Lake, California. The cost of wind power generation compared favorably with the present energy cost at Grand Turk, Barrow, Eleuthera, San Nicolas, and Adak Islands.

Planned Milestones (Completion Dates)

—Analyze data from tests of 5-kw machine.
—Prepare technical note on 5-kw wind generator test results from Laguna Peak/San Nicolas Island.

Milestone completion dates for the project are yet to be determined.

Self-Sufficiency
Category 6.2
NAVFAC

Feasibility of Small-Scale Vertical-Axis Wind Machines

Objective

The objective is to provide analytical and testing support to the vertical-axis demonstration program at NWC, China Lake.

Technical Approach

Following award of a contract for procurement and installation of vertical-axis wind machines at a Navy site, data recording systems will be installed. Data will be analyzed and a technical memorandum prepared on the 1-kw wind turbine demonstration.

FY 1976/77 Progress

Three machines were installed at NWC, China Lake. The contractor is adjusting the machines before starting the field tests.

Planned Milestones (Completion Dates)

December 1978—Analyze results of 1-kw wind turbines to demonstrate building environmental control at NWC, China Lake.
May 1979—Analyze data from the field demonstration at NWC, China Lake.
June 1979—Prepare technical memorandum on 1-kw wind turbine demonstration.

Handbook for Application of Wind Power Generators at Naval Facilities

Objective

The objective is to prepare, and revise as required, a handbook for application of wind power generators to Navy activities.

Technical Approach

Field data collected from the 1-kw and 5-kw tests will be analyzed to obtain the performance parameters of the wind generator unit and of the power conditioning hardware required for practical use of wind power. A handbook will be written describing the computation of design parameters, such as power coefficient, the specific power output, and the cost of wind energy generation for a wind power system at a given location. The handbook will be updated as results become available from field demonstrations in the advanced and engineering development programs of 10-kw generators and 100- to 1,500-kw wind power systems.

FY 1976/77 Progress

Computer routines for analyzing the field data were developed. Because data from the field tests are not yet available, no major analyses have been done. The program uses site wind data to compute power duration curves and energy patterns. A data tape from 1-kw machine demonstration at NWC, China Lake, was received recently.

Planned Milestones (Completion Dates)

May 1977—Develop computer routines for analyzing data from field demonstration.

September 1977—Analyze data from 1-, 5-, and 10-kw wind generator tests at NWC, Laguna Peak, and CEL, respectively.

June 1979—Compile results from the various field demonstrations and prepare handbook for Navy applications of 1- to 5-kw wind generators.

June 1984—Revise and update the handbook to include the 1-kw, 5-kw, and 10-kw wind generator demonstrations results and new developments.

September 1984—Revise and update handbook to include 100- to 200-kw wind generator results and new developments (by contract).

September 1985—Revise and update handbook to include 1,500-kw wind generator (by contract).

Site Selection for Installation and Testing of 100- to 1,500-kw Wind Generators

Objective

The objective is to select a feasible site to install and test an ERDA-developed 100- to 1,500-kw wind generator based on cost-effectiveness and local wind characteristics.

Technical Approach

A preliminary investigation will be conducted to determine candidate sites where the application of a 100- to 1,500-kw capacity ERDA wind generator will be cost-effective. Next, long-term field measurements to determine the wind characteristics of the site will be taken and analyzed for proper siting of the 100-kw unit at one of the candidate sites. If a site is selected, installation and testing of a 100-kw wind generator in the FY 1979 NAVFAC engineering development program would result.

FY 1976/77 Progress

Important developments in the ERDA wind turbine generators were followed and analyzed for their applicability to Navy use. An investigation is underway to develop detailed wind load and other related parametric characteristics of the 10 candidate sites. The final selection of a site will be based on the information gain through personal contacts or visits to each site.

A technique for longitudinal correlation of wind data with its applications to siting of wind power plants was developed. The method is based on correlating the long-term historical data for a region with measurements at the site in question for a relatively short period of time.

Planned Milestones (Completion Dates)

September 1977—Follow the development of the 100- to 1,500-kw ERDA wind generators.

September 1977—Conduct a preliminary investigation to select candidate sites for field tests of the 100-kw wind generator.

Geothermal Utilization Technology for Remote Sites

Objective

This effort is aimed at identifying ongoing Navy energy technology development programs having potential application to geothermal systems. Also, equipment being developed within the geothermal industry and suitable for use at remote Navy installations will be identified and tested at Navy locations.

Technical Approach

Navy energy programs will be surveyed to identify those devices under development that could be easily adapted for use with geothermal power sources. Also, programs under ERDA and industry sponsorship will be reviewed to identify devices that would be particularly useful to the Navy.

FY 1976/77 Progress

Development programs at CEL have been surveyed. Air conditioners for use with solar energy and bottoming cycle Rankine power generators will be adaptable in the future; however, hardware is not now available for experiments with geothermal fluids.

ERDA has under development one device for geothermal power production that has importance for Navy application. The device, Helical Screw Expander being developed by the Hydrothermal Power Company, uses commercially avaiable parts, can be built to generate up to 5 Mw per unit, and is applied directly at the wellhead. It can be pallet-mounted and will operate with a variety of fluids, which makes it very attractive for remote Navy applications. A 2.5 Mw unit is being assembled and should be ready at about the same time that the Coso well drilling operation is completed (late summer). The Coso well, if successful, would provide an ideal test site for this device.

Planned Milestones (Completion Dates)

September 1977—Survey equipment.

Navy Geothermal Site Assessment

Objective

All Navy sites will be surveyed to determine (1) which sites have potential for geothermal resources and (2) through geologic interpretation and evaluation, the order in which the sites should be explored.

Technical Approach

The geothermal potential of Navy bases throughout the world will be judged on the basis of their proximity to areas of high seismicity and geologically recent volcanic activity. Those installations having appropriate land resources and geothermal potential will then be evaluated through literature search and analysis and, in some cases, field evaluation. Results will be used to rank the locations with respect to their geothermal potential. This will provide the principal input for detailed geological/geophysical studies.

FY 1976/77 Progress

Navy bases have been evaluated with respect to their seismic activity and proximity to recent volcanic activity. The University of Utah has been tasked with evaluating individual sites under NWC direction. Among those sites evaluated to date are Guam, Naples, Okinawa, and the Gulf Coast installations.

Planned Milestones (Completion Dates)

April 1977–Complete preliminary list of Navy sites.
September 1977–Evaluate and rank Navy geothermal sites.

Adak Geothermal Resource Development

Objective

This task will assess the potential of the Adak geothermal resources to provide electrical power and space heating for Navy facilities on that island.

Technical Approach

Geological/geophysical field studies will be conducted by the U.S. Geological Survey (USGS) to obtain a preliminary assessment of the geothermal potential. If promising, a site will be recommended for exploratory drilling. An economic utilization study will be conducted to determine the merit of exploiting the resource, should one be available, and will be funded under Category 6.5.

FY 1976/77 Progress

Phase I geophysical studies were completed during the summer of 1976. The geochemical analysis of surface thermal waters revealed the possibility of fluid temperatures of 300° F or better. The geophysical techniques employed included magnetic, gravity, and self-potential surveys as well as audiomagnetotelluric and telluric traverses. Results were promising and drilling was recommended.

Phase II geophysical work was conducted by the USGS during the spring of 1977. Additional electrical potential work resulted in selection of a drilling site in northern Adak. The site is within 5 miles of the Navy facilities on Adak and, if successful, could provide both electrical power and fluids for heating.

Economic studies indicated that use of geothermal resources at Adak would be very attractive. Even at zero growth rate and zero fuel cost escalation, the system will pay for itself in less than 8 years.

Planned Milestones (Completion Dates)

September 1976—Complete Phase I geological studies at Adak.
June 1977—Complete Phase II geological studies at Adak.

Coso Geothermal Resource Development

Objective

This task is aimed at evaluating the results of the USGS and ERDA geological/geophysical studies at the Navy's Coso Thermal Site.

Technical Approach

The drill core and data from the ERDA-sponsored drilling effort at Coso will be examined by NWC, China Lake, to determine the resource's characteristics and the geothermal potential involved at the site. This information will be correlated with USGS surface studies to provide further insights into both the Coso resource and the accuracy of surface evaluation methods.

FY 1976/77 Progress

The drill core from the early drilling by Battelle/Northwest Laboratories and data taken during the drilling effort were obtained. A total of 16 shallow (100 meter) heat flow holes were drilled by Battelle before drilling the deep hole. Problems with the Battelle drilling effort resulted in termination of the slim-hole drilling at a depth of 1,300 feet. ERDA, using its Nevada Operations Office, plans to continue the drilling with a full-size rig during the fall of 1977. This task will continue in support of that effort.

Planned Milestones (Completion Dates)

December 1977—Complete evaluation of drilling data.

Geothermal Legal/Institutional Study

Objective

This study will (1) identify and explore the institutional, legal, and operational interface considerations that exist in the exploration, development, and exploitation of geothermal resources on and adjacent to Navy property, and (2) provide guidelines to the Navy on the use and management of such resources.

Technical Approach

A number of possible geothermal development scenarios will be generated based on actual experience at Coso, Adak, and Lualualei, and on projections of possible future programs. These scenarios will be examined with respect to local, state, and federal regulations and institutions. Problems and action options will be identified and recommended courses of action tendered. A report will be written to aid the Navy in particular, and DOD in general, in developing geothermal resources on their lands.

FY 1976/77 Progress

The geothermal scenarios have been developed, the legal literature searched, the institutions involved in geothermal development investigated with respect to their roles, and recommended courses of action developed. The final report is being prepared. In addition, the program has provided specific answers to questions on development at the Navy's Coso Thermal Area at NWC, as well as on development of resources on Adak and Lualualei.

Planned Milestones (Completion Dates)

February 1977–Identify and rank problems.
March 1977–Conduct legal search.
May 1977–Identify and catalog institutions.
September 1977–Prepare final report.

Geothermal Impact on Navy Missions

Objective

This task is aimed at identifying and documenting the potential impact of geothermal exploration, development, and utilization on the basic missions of Navy shore facilities.

Technical Approach

Basic Navy missions will be identified and geothermal exploration, development, and utilization operations characterized. These data will subsequently be used to determine the effect of geothermal operations on basic Navy missions.

FY 1976/77 Progress

The basic missions have been identified and geothermal operations characterized.

Planned Milestones (Completion Dates)

January 1977–Characterize geothermal exploration, development, and operations for power and heat.
March 1977–Identify impact of geothermal activities on typical operations at Navy bases.
September 1977–Document study results.

Geothermal Corrosion Studies

Objective

The objective is to explore the causes and nature of corrosion of construction materials resulting from contact with geothermal fluids.

Technical Approach

Corrosion arrays consisting of whole and half-sectioned pipes of various construction materials will be exposed to a number of geothermal fluids. The first tests will be run using near-surface and surface geothermal fluids at the Coso Thermal Area. Later tests will be made using fluids from the deep well at Coso and from wells at specific Navy locations such as Adak and Lualualei. After exposure to these fluids, materials will be metallurgically examined and corrosion mechanisms determined.

FY 1976/77 Progress

The initial three corrosion arrays have been exposed to the near-surface fluids at Coso for 6 months. These fluids included steam/water mixtures from the Devil's Kitchen acid sulfate environment, steam off the Coso Resort reservoir, and fluids pumped from the 375-foot depth at the Coso Resort. With the assistance of the Naval Postgraduate School (NPS), Monterey, materials have been analyzed and a report on findings will be published shortly. Arrays re-equipped with materials recommended by NPS will soon be put on-line. Additional arrays are planned for the Coso deep hole and for the exploratory well to be drilled at Adak.

Planned Milestones (Completion Dates)

January 1977–Complete chemical and metallurgical studies of samples corroded last fiscal year to determine corrosion processes, products, and rates.
June 1977–Place new arrays on-line at Coso Thermal Area.

Self-Sufficiency
Category 6.2
NAVFAC

Preliminary Analysis of Combined Solid and Liquid Waste Processes

Objective

The objective is to provide preliminary data and analysis necessary for design and development of a prototype liquid and/or solid waste recycling system for application at Navy bases.

Technical Approach

Combined liquid and solid waste processes can make a significant contribution to the energy self-sufficiency of remote forces and bases, and such closed-cycle processes would be applicable where air pollution control for conventional incineration is prohibitive. A technology survey indicates that wet-air oxidation and anaerobic digestion processes, or a combination of the two, are good candidates to provide a net, direct energy output from a low-capacity system. A detailed analysis of the net energy recovery potential of slurry processes compared with that of dry (burning or decomposition) processes and the inherent requirement for dewatering and/or evaporation in the latter will be based on typical Navy liquid and solid waste compositions. The ERDA Office of the Assistant Administrator for Conservation (AC) is funding a 50- to 100-ton-per-day anaerobic digestion plant. This proof-of-concept plant for sewage sludge and light-fraction municipal waste, together with other ERDA-sponsored R&D on methane generation and bioconversion, should provide valuable data. ERDA's primary interest is to scale up to municipal and large industrial applications; most Navy applications would require scaling down from the size of ERDA's proof-of-concept digester.

FY 1976/77 Progress

Information on wet-air oxidation and anaerobic digestion processes was acquired from ZIMPRO, Inc., and ERDA, respectively. The technology survey indicates that wet-air oxidation, anaerobic digestion, or a combination of the two are good candidates to provide a net, direct-energy output from a low-capacity system. Data were obtained on a gasoline process that may use sewage sludge of proper solids concentration. Manufacturers of dewatering filters were also contacted.

A technical memorandum on the technology survey was written.

CEL is investigating low technology, low capital concepts for retrofitting Navy waste-treatment plants to produce methane. Data are being obtained on Navy waste-treatment plants and on energy-recovery processes involving sludges or slurries. Additional data were assembled on the potential for using an anaerobic digestion process that produces synthetic gasoline.

Preliminary economic analysis for Navy-size (serving 10,000 to 15,000 people) wet-air oxidation or anaerobic digestion plants indicates highly improbable payoff. However, ZIMPRO is working on multi-fueled wet-air oxidation plants using coal as well as liquid and solid wastes.

Planned Milestones (Completion Dates)

April 1977–Evaluate Navy plants for retrofit to methane production.

September 1977–Monitor work by others and prepare a technical memorandum on FY 1977 work.

May 1978–Perform comparative analysis of theoretical and practical energy recovery efficiencies of liquid/slurry processes and processes involving dewatering or drying.

September 1978–Analyze costs of alternative systems (by contract).

Small-Scale Densified RDF Process Equipment

Objective

The objective is to determine the parameters desirable in densified RDF for direct thermal conversion to energy in small packaged units.

Technical Approach

Past work in refuse densification at CEL has dealt primarily with feasibility and processing techniques for stability, transportability, and disposability, including the option of direct ocean disposal.

Energy program effort will involve handling and comparative burning tests of various densified RDFs, as well as of other forms of processed and unprocessed RDF, to determine the parameters desirable in a densified RDF for many packaged incinerators. Reprocessing densified RDF for use in combined liquid and solid waste processes may be investigated, depending on which combined processes are determined most suitable for Navy use. Other sources of funding such as ERDA (AC) will be investigated to hasten completion of this product, or its potential transition to Category 6.3/6.4 funding.

FY 1976/77 Progress

The U.S. Army Civil Engineering Resource Laboratory was given a work request to investigate sources of RDFs and problems associated with small-scale combustion of RDF for direct thermal conversion. Hardware requirements and possible sources of RDFs for small-scale combustion tests in a packaged incinerator were identified. A test plan is being developed.

Planned Milestones (Completion Dates)

May 1977–Develop test plan for burning experiments with various RDFs.
July 1978–Procure support equipment and conduct comparative burning tests with various refuse fuels.
September 1979–Develop prototype design criteria for operational scale testing of densified RDF processing.

Conversion of Solid Waste to Gasoline

Objective

The objective is to develop and demonstrate the technology needed to produce petroleum-like products (principally high octane gasoline) from the organic fraction of trash and to quantify the gasoline yield and energy efficiency.

Technical Approach

The method to be demonstrated and quantified will use a three-step process: (1) pyrolysis to produce olefins, (2) purification of pyrolysis gases to concentrate olefins, and (3) polymerization of olefins to gasoline. Raw municipal solid waste will be separated into organic and inorganic process streams using techniques now in full-scale development. The organic fraction will be pyrolyzed to form gaseous hydrocarbons suitable for purification and polymerization to high octane gasoline. By-product gases and char will be used to supply the process energy.

FY 1976/77 Progress

As of March 1977, selective pyrolysis of organic waste to olefins had been successfully demonstrated. This pyrolysis has yielded a 25 percent by weight conversion on a dry, ash-free basis (50 percent energy conversion). Pure ethylene (the predominant olefin) has been reacted (polymerized) to form a synthetic crude oil containing 90 percent gasoline having a nonleaded motor octane of 90. Preliminary economic evaluations have indicated that, using military economic rationale, a 100-ton-per-day plant would be economically attractive at gasoline prices above $0.42 per gallon. Additional bench-scale process development work is in progress, but no significant technical problems are anticipated.

Planned Milestones (Completion Dates)

FY 1978—Establish scale-up parameters and follow through scale-up.

Site Characteristics

Objective

The objective is to assemble energy-related environmentally derived data for Navy bases for use by researchers and planners in the energy area.

Technical Approach

Environmental and resource data available from sources such as the Environmental Data Service of the National Oceanic and Atmospheric Administration (NOAA) and USGS will be analyzed and supplemented by measurements taken at Navy sites where data have not been taken previously. There is an absence of solar (insolation) data at numerous Navy bases and a history of pyranometer calibration problems exists that requires careful analysis of existing data and collection of new data. Since wind speed is critically dependent on terrain, a great deal of on-site measurement of wind data will be required over and above local weather station records. Waste material properties and production rates have not been available for Navy bases in enough detail to evaluate the benefits of solid or liquid waste energy conversion. Solid waste data acquisition will be coordinated with the NAVFAC solid waste energy RDT&E program (YF 57-571-999). Geothermal data are being collected as part of the activities in the "Navy Geothermal Site Assessment."

FY 1976/77 Progress

A potentially useful relationship between heating and cooling degree-days and climate was determined. Oceanic or maritime climates have significantly lower heating and cooling degree-days. In these climates, ambient air temperatures are determined almost exclusively by the nearby or surrounding oceanic water mass. These conditions prevail at island and windward side coastal locations. Inland and leeward continental temperate locations tend to have both higher heating and cooling degree-days. With this relationship, it should be possible to estimate missing cooling degree-days, given location and heating degree-day data. The relationship might also be used for classifying locations for energy demand as a function of climate and/or latitude.

The Solar Heating and Cooling Demonstration Act survey of family housing was extended from 47 to 121 family housing units.

An energy engineering data bank is being planned. The immediate need is for ready access by CEL to the available data on site characteristics.

The Energy Data Mobile Laboratory (EDML) has been acquired, checked out, and partially equipped. Plans for modifying the EDML to include instrumentation for this project have been made.

An operational test of the weather measure Model 20-CHD tower and trailer has been made. It is possible for one man to go through the complete erection and retraction cycle of the solar and meteorological instrument bearing tower in only six minutes. The necessary guy wire stringing was not included in this test.

A trip to Centerville Beach, California, by way of Palo Alto and Treasure Island was made by the EDML as a simultaneous shakedown cruise, check on instrumentation to be delivered, survey of the first test site, and safe pick-up of solar and meteorological instrumentation that had been installed at Centerville Beach on another project and that now belongs to this project.

Operational tests of the solar and meteorological equipment were performed at Centerville Beach, Port Hueneme, and San Nicolas Island, California.

Calibrations and recalibrations of the Rho Sigma photovoltaic pyranometers were made by the manufacturer.

The project investigators represented the Navy Energy Program at a working meeting on Solar Radiation Measurements at MERADCOM, Ft. Belvoir, Virginia, 22 and 23 March 1977. MERADCOM is the lead laboratory for DOD solar (photovoltaic) projects.

A cell energy program is being developed in long-term coordination with ERDA and NOAA. Solar and meteorological instrumentation necessary for the 35 tentative DOD-wide sites will be determined. From their project experience, CEL proposed an instrumentation system that could save at least half of the original estimated cost for the DOD site measurements.

Deciphering of six, nine-track, high density, computer data tapes obtained from the Navy detachment at the National Climatic Center at Asheville, North Carolina, has commenced. These tapes contain detailed IGY (International Geophysical Year) meteorological data for 60 key Navy sites and is considered to be good data for basic long-term appraisals.

The usual data compilation assistance was provided to the CEL energy staff.

Planned Milestones (Completion Dates)

Continuing—Acquire, analyze, and reduce solar, wind, and other energy-related meteorological data. Report annually.

Continuing—Acquire and analyze waste material production and property data. Report annually.

Continuing—Survey and assess ocean and geothermal resource data with regard to Navy base utilization. Report annually.

January 1977—Plan, design, and procure equipment and instrumentation for the field measurement of energy-related meteorological data.

September 1977—Measure energy-related meteorological data at two bases during one 3-month period at each site.

Evaluation of New Coal Technologies

Objective

The objective is to provide recommendations on the applicability of new coal technologies for Navy facilities.

Technical Approach

New technology demonstrations will be evaluated to enable the Navy to take advantage of new coal systems as soon as practicable. The ERDA fluidized-bed boiler demonstration will be monitored by the Energy Program Office to provide the technical support needed to incorporate the boiler into the Navy system if the demonstration is successful. The applicability of new developments in coal liquefaction to provide petroleum-like fuels for the Navy will also be monitored.

Emission reduction techniques for particulates, sulfur oxides, and nitrogen oxides will be investigated. New developments in coal beneficiation technology, primarily the removal of pyritic sulfur, appear particularly attractive for industrial-sized boiler applications. Accordingly, the energy program will support part of the magnetic separation of pyritic sulfur investigation in progress at the Naval Ordnance Station in Indian Head, Maryland.

FY 1976/77 Progress

The contract for the ERDA fluidized-bed boiler demonstration at the Great Lakes Naval Training Center site was awarded to Combustion Engineering in July 1976. The State of Illinois and EPA are also participating.

CEL investigated several projects involving new developments in coal beneficiation technology, primarily the removal of pyritic sulfur. These projects included a demonstration of magnetic separation of pyritic sulfur and thermal separation of organic sulfur (Georgia Power Company and ILOK Power Company), demonstration of the Meyers process for leaching organic and pyritic sulfur (Battelle Northwest). CEL also contacted General Motors about its double-alkali scrubber at Parma, Ohio.

CEL continued its study of retrofit fluidized-bed boiler applications.

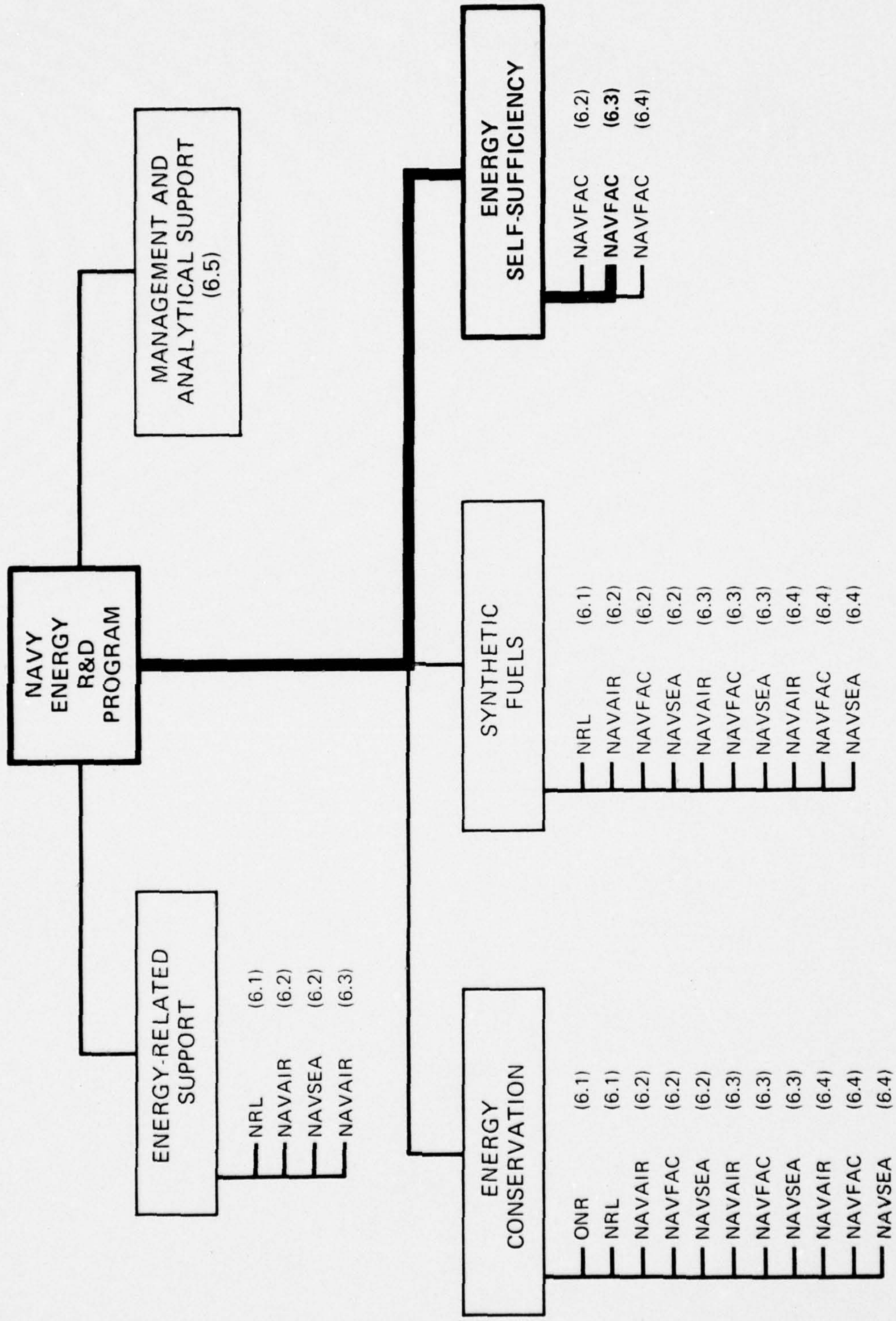
Planned Milestones (Completion Dates)

September 1981–Support pyrite removal investigation at the Naval Ordnance Station, Indian Head.

Continuing–Contract for coal resources and fluidized-bed technical consultation. Renew as required.

Continuing–Support ERDA fluidized-bed boiler demonstration.

ENERGY SELF-SUFFICIENCY
ADVANCED DEVELOPMENT (6.3)
NAVFAC


NAVY ENERGY R&D PROGRAM
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
ENERGY CONSERVATION
ONR (6.1)
NRL (6.1)
NAVAIR (6.2)
NAVFAC (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
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NAVSEA (6.3)
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SYNTHETIC FUELS
NRL (6.1)
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ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
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NAVFAC (6.4)

4.3 ADVANCED DEVELOPMENT (6.3)

4.3.1 NAVFAC
Shore Facilities
Energy Self-Sufficiency
P.E. 63724N
Z0840

Introduction

Exploratory level efforts may show that various degrees of design modification are needed for Navy application of some energy technologies and/or equipment before starting a full-scale demonstration at a Navy site. This may involve scaling down requirements, unique site and/or equipment characteristics requirements, or improvements in the state-of-the-art. Prototype design studies concurrent with economic analysis and limited field testing will furnish the data required to decide if a particular system is practical for Navy application where reduced dependence on conventional fuel supplies is needed.

Applicability of a Photovoltaic System

Objective

The objective is to demonstrate the applicability of a photovoltaic system at an advanced Navy base.

Technical Approach

Currently available equipment selected on the basis of data and information gathered under exploratory development will be built and demonstrated at an advanced base.

FY 1976/77 Progress

The project will begin in FY 1979.

Planned Milestones (Completion Dates)

FY 1979—Demonstrate photovoltaic system.

Preliminary Design of a Solar Desalination System

Objective

NAVFAC is preparing a preliminary design for a full-scale solar desalination plant.

Technical Approach

The system will be designed based on feasibility studies and analysis under exploratory development work.

FY 1976/77 Progress

The project will begin in FY 1978.

Planned Milestones (Completion Dates)

September 1978–Prepare preliminary design for a full-scale solar desalination plant.

Self-Sufficiency
Category 6.3
NAVFAC

Advanced HVAC System Testing--Solar-Augmented Heat Pump (SAHP)

Objective

The objective is to investigate the feasibility and advantages of using SAHP in HVAC applications. If economical systems can be identified, a test unit will be designed and tested in the AEUTB.

Technical Approach

The SAHP project involves investigation and development of a concept that consists of a heat pump assisted by collected solar energy for heating and nighttime radiation for cooling. The object of this effort will be to determine the best arrangement and size of components in the system. Once this information has been determined, an experimental system will be built and tested to verify the results. A demonstration will follow to transfer the knowledge gained to the field activities.

FY 1976/77 Progress

Much work has been done over the past 30 years by individuals. Currently, ERDA's Office of Conservation and the Electric Power Research Institute are pursuing this concept. Generally, the systems tested have raised the seasonal performance factor, which is a seasonal coefficient of performance term and therefore a measure of energy savings. Computer simulations of alternative systems have been completed, as well as the final design of the system to be installed in the AEUTB.

Planned Milestones (Completion Dates)

March 1978—Design and install the experimental SAHP system in the AEUTB.

September 1978—Prepare contract documentation for the demonstration of the design principles of efficient operation of air conditioning equipment at part load in new and existing applications.

September 1979—Test possible configurations and operating modes of concepts for retrofit SAHP systems in the AEUTB. Prepare technical memorandum for distribution on FY 1978 results.

Demonstration of Energy Storage Techniques

Objective

The objective is to demonstrate storage techniques and to integrate storage systems with local energy sources such as solar and wind energy.

Technical Approach

Based on evaluations resulting from exploratory development work, storage systems will be selected for fabrication and installation at Navy sites where exploitation of solar and wind energy is planned.

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

June 1978—Monitor contract of chemical storage.
September 1978—Publish contractor's report.

Demonstration of Solar Air-Turbine Generator

Objective

The objective is to design, construct, and test a solar air-turbine generator for application at advanced Navy bases.

Technical Approach

Prototype design of the solar air-turbine generator will have been completed under the exploratory development program. Fabrication and testing of the generator will be by contract.

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

May 1979—Contract for design and fabrication of prototype.

September 1979—Conduct acceptance and check-out tests on prototype solar-electric turbine generator unit.

September 1980—Contract for periodic delivery of additional solar-electric turbine generator site for testing.

March 1981—Conduct performance tests on units at selected sites.

September 1983—Perform tests on parallel connected units at central solar-electric test site.

September 1984—Prepare specifications for production of Navy solar-electric turbine generator systems.

Alternate HVAC Systems Testing

Objective

The objective is to demonstrate alternate HVAC systems.

Technical Approach

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

September 1978—Prepare contract documentation for the demonstration of the design principles of efficient operation of air conditioning equipment at part load in new and existing applications.

March 1982—Demonstrate the design principles of efficient operation of air conditioning systems at part load in new and existing applications.

Testing of 5- to 10-kw Capacity Wind Generators to Supply Power for Buildings

Objective

The objective is to develop additional hardware for converting wind energy to either heat for buildings or to 60 Hz constant voltage electricity.

Technical Approach

A wind generator comprised of either one 10-kw unit or three 3-kw units will be selected and installed at the AEUTB for demonstration. Power conditioning will be designed based on results of tests of a 5-kw generator, and additional hardware will be developed for converting wind energy to:

- Heat water for the heat storage tank using an immersion-type electric heater.
- Operate a fan for attic ventilation.
- Illuminate buildings.
- Operate compressors, heat pumps, water pumps, and electric motors.
- Operate kitchen appliances such as conventional or microwave ovens.
- Operate other miscellaneous loads.

In addition, a site will be selected from the list of 11 candidate sites based on the NWC study for a 4-year field demonstration.

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

December 1977—Design and procure power conditioning for 10-kw plant at the AEUTB site.

December 1977—Select four demonstration sites for the 10-kw wind generators from the list of 11 candidate sites based on NWC study.

September 1980—Test 1-kw and 10-kw wind power plants at the AEUTB site.

April 1978—Install and conduct check-out test on the power conditioning equipment for the 10-kw plant at the AEUTB site.

April 1978—Perform design modification on the 1-kw wind turbines to operate refrigeration type air conditioners for building environmental control.

FY 1978—Conduct field demonstration at NWC, China Lake.

June 1978—Prepare statement of work for the development of a 10-kw vertical axis wind-driven heat and electric generator.

October 1978—Award contract for the development of the 10-kw heat and electric generator (estimated award date is August 1978).

March 1979—Select and prepare a site for the field demonstration of the 10-kw generator.

April 1980—Test the 10-kw generator for 1-year field demonstration.

September 1980—Analyze data from the 10-kw unit field demonstration.

Application of ERDA-Developed 100-kw Wind Generators

Objective

The objective is to determine the applicability of ERDA-developed 100-kw wind generators for bulk power supply at Navy bases, through determination of cost and performance data.

Technical Approach

Following site selection under the exploratory development program, a 100-kw unit will be procured and integrated with the base grid for a 3-year period of tests and evaluation. Data collected will include performance of the unit, including maintenance costs and cost of energy generation. Experience obtained through operation of the 100-kw unit will be used for site selection, installation, and testing of a NASA/ERDA 1,500-kw wind generator system at a Navy base.

FY 1976/77 Progress

This project will begin in FY 1979.

Planned Milestones (Completion Dates)

Continuing—Follow the development of the 100- to 1,500-kw NASA/ERDA wind generators.

November 1977—Conduct an investigation to determine the locations for field weather measurements.

September 1978—Install weather measuring equipment at various locations and collect measurements.

January 1979—Analyze field data to select the best site for the 100- to 200-kw field demonstration.

March 1979—Prepare contract schedule to procure and install the 100- to 200-kw wind generator at a selected base for a 3-year test and evaluation project (estimated award date is June 1978).

December 1979—Install 100- to 200-kw wind generator at selected base (by contract).

September 1982—Test 100- to 200-kw wind generator.

Adak Geothermal Resource Development

Objective

This task will further assess the potential of the Adak geothermal resources to provide electrical power and space heating for Navy facilities on that island.

Technical Approach

Based on results and analysis of field studies and exploratory development, an exploratory well will be drilled to verify the resource and characterize the associated fluids.

FY 1976/77 Progress

The drilling was initiated during the summer of 1977.

Planned Milestones (Completion Dates)

September 1977—Drill exploratory well.

Investigation of Geothermal Sites

Objective

The objective is to evaluate the potential of geothermal deposits at Navy facilities.

Technical Approach

Based on evaluations of the worldwide survey of Navy bases (6.2 funding), sites that appear to have the most promising geothermal assets will be evaluated in more detail. Surface geophysical, geochemical, and geological studies will be conducted to better assess a given location's geothermal potential. If promising, areas for exploratory drilling will be identified. Economic utilization studies will also be conducted during the first phase to determine if geothermal development of a site in support of the Navy mission is economically sound when compared with other energy options. If both the surface geology and economic study prove favorable, the next step will be exploratory drilling to prove geothermal potential and characterize the geothermal fluids involved. The end result will be a full assessment of Navy geothermal areas and utilization.

FY 1976/77 Progress

The first tentative site selection resulted from a proposal by a private company to drill at Lualualei on Oahu, Hawaii. They proposed to drill at their expense and, if successful, develop the area and sell power to the Navy. As of March 1977, the possibility of doing this is still being examined by the Navy and NWC is providing geological assessments and assistance to determine the legal difficulties as well as the environmental and legal effects. Should the program move ahead, NWC will provide technical assistance.

Planned Milestones (Completion Dates)

FY 1978–Conduct Phase I geological studies of Lualualei.
FY 1979–Conduct utilization and economics study of Lualualei.
FY 1979–Conduct Phase II geological studies of Lualualei.
FY 1980–Drill exploratory slim-hole well at Lualualei.

Demonstration of Packaged Heat-Recovery Incinerator

Objective

The objective is to demonstrate applicability of packaged incinerator systems for Navy bases.

Technical Approach

Initial tests with unprocessed waste fuel are expected to demonstrate that nearly 50 percent of total life-cycle costs to the Navy are attributable to nonautomated operator labor. Additional preliminary tests with prepared RDF will define parameters and components needed for remotely monitored operation. The demonstration prototype will be upgraded for automation in FY 1979, and operational testing through FY 1980 will precisely define the costs and effectiveness of the system in numerous operating modes. Colocation of this demonstration prototype with a solid waste program transfer/processing prototype is planned for mutual support. The Environmental Protection Agency's Office of Solid Waste Management (EPA, OSWM) has conducted tests of a few hours duration on several packaged, controlled-air-type incinerators. These tests have indicated acceptable burning capacities and stack emissions. EPA's interest is primarily for municipal applications, which generally would not involve continuous operation and which may also not require heat recovery.

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

September 1978–Procure and install components of basic demonstration prototype.
March 1979–Perform initial tests to determine parameters for full automation.
August 1979–Design and install components for storage and auto loading of RDF.
September 1980–Complete testing and demonstration for comparative evaluation of various operating modes, including different RDFs and report results.

Design and Demonstration of Combined Liquid and Solid Waste Processes

Objective

The objective is to demonstrate a small prototype system for recycling combinations of solid and liquid wastes to energy.

Technical Approach

Analysis of data resulting from exploratory development work, as well as results of ERDA's R&D planned for an anaerobic digestion plant, will allow advanced development of a prototype liquid or solid processing system scaled for application at Navy shore facilities. Design and construction of a demonstration prototype will be contracted and scheduled for completion in FY 1980. System shakedown testing, any needed modifications, and final testing and documentation of results will be completed during FY 1980-81.

FY 1976/77 Progress

This project will begin in FY 1979.

Planned Milestones (Completion Dates)

April 1979—Develop design and cost estimate for prototype system (by contract).
August 1980—Select advanced development site and construct prototype.
September 1982—Test prototype and report results and recommendations.

Small-Scale Densified RDF Process Equipment Testing

Objective

NAVFAC is obtaining data on an RDF system operating with a variable waste stream and producing various RDFs.

Technical Approach

A contract will be awarded, possibly with ERDA support, by September 1977 for installation of a 100-ton-per-day RDF system at Norfolk. The system will be fed a variable waste stream and will produce various RDFs to obtain data from a working system to verify the theoretical data. A 3-year testing period is planned.

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

September 1977—Award contract.
FY 1979—Ready RDF system for operation.
FY 1979-81—Test RDF system.

Development of a Navy Energy Self-Sufficiency Plan/Demonstration

Objective

NAVFAC is developing a plan that provides guidelines to Navy installations for selection, identification, and integration of alternative energy sources that would provide maximum level of self-sufficiency.

Technical Approach

An exemplary plan and demonstration at NWC, China Lake, will be accomplished in three phases. In Phase I, NWC's energy needs will be analyzed and available alternate energy resources, viable energy storage systems, and any environmental, legal, or mission impacts that might result from the proposed program will be identified. Considering the possible effects, energy requirements identified will be matched to the available alternative energy resources. Preliminary designs will be developed for the more promising options and a data base established for costs, risks, technical difficulties, and systems impacts. Phase I will conclude with the preparation of a data package, including a proposed plan for development, which will serve as the basis for a decision on the Phase II effort.

During Phase II, a contract will be let to an architect-engineering organization for the purpose of conducting a systems design of the NWC self-sufficiency system. Through this contract effort, detailed cost data can be obtained and a better evaluation made of the potential risks and impacts. Research and development work will continue in those areas needed for NWC self-sufficiency where technical deficiencies exist.

Following a review at the end of Phase II, there will be a two-part Phase III effort. Phase IIIA will include a detailed design of the system and the initiation of procurement of long-lead-time items. Construction of the required systems will be accomplished during Phase IIIB.

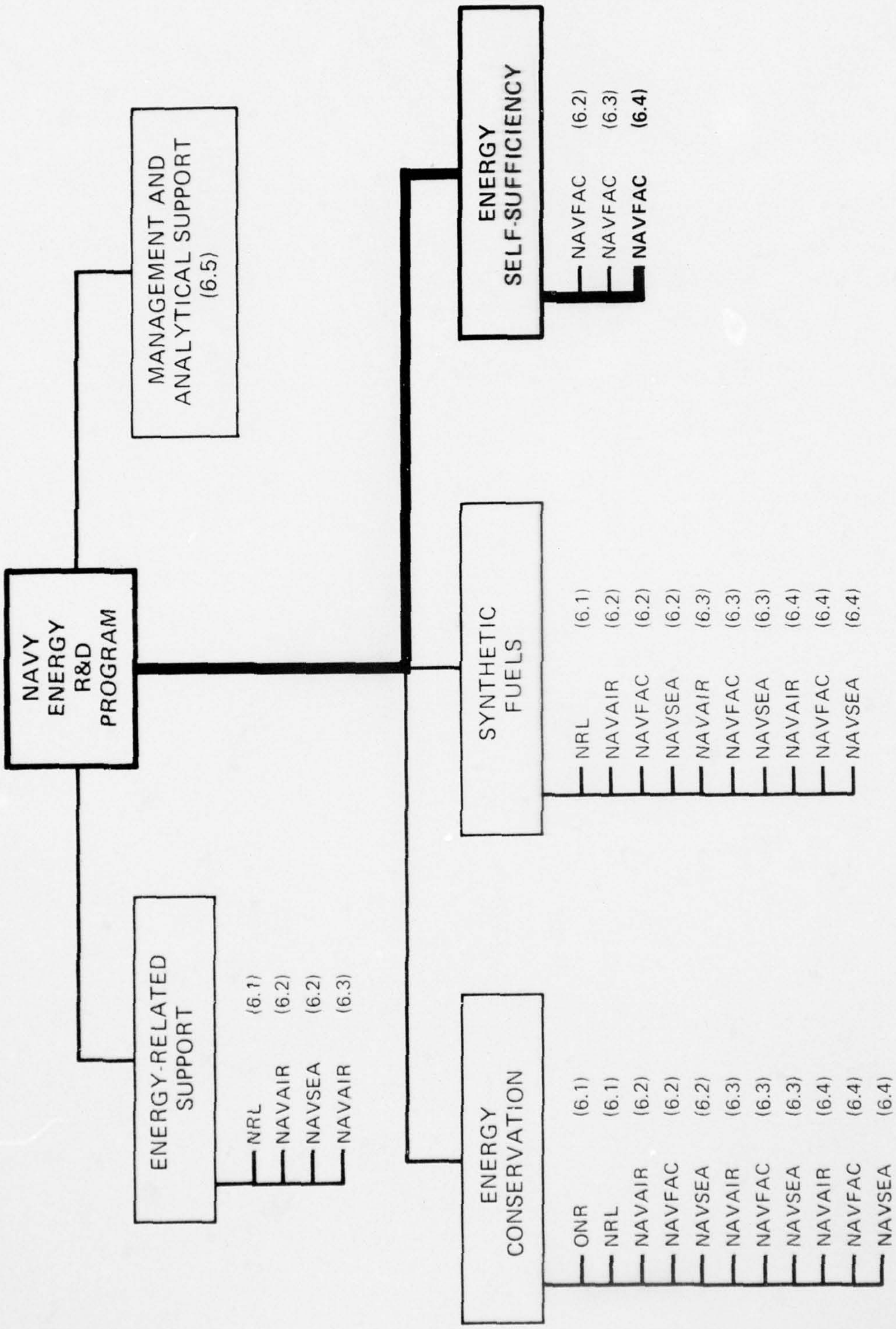
FY 1976/77 Progress

Work on the basic program plan continued through March 1977 and is nearly completed. Analyses of NWC energy needs characterization and identification of energy resources were started. Data on solar, wind, and geothermal resources are also being collected.

Planned Milestones (Completion Dates)

September 1978–Complete Phase I.
September 1979–Complete Phase II.
September 1981–Complete Phase IIIA.
September 1986–Complete Phase IIIB.

ENERGY SELF-SUFFICIENCY
ENGINEERING DEVELOPMENT (6.4)
NAVFAC


NAVY ENERGY R&D PROGRAM
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY CONSERVATION
ONR (6.1)
NRL (6.1)
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NAVSEA (6.4)
ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
NAVFAC (6.3)
NAVFAC (6.4)

4.4 ENGINEERING DEVELOPMENT (6.4)

4.4.1 NAVFAC
Shore Facilities Energy Self-Sufficiency
P.E. 64710N
Project Number Z0350

Introduction

A limited number of projects will be ready for the engineering development phase immediately following state-of-the-art studies at the exploratory development level because they rely heavily on technology being developed in the civilian sector (ERDA programs). In such cases, full-scale demonstration of a system at a carefully selected Navy site would use technology that is commercially available or ERDA-developed to obtain maintenance and reliability data and technical feasibility data. The results may be unique for a particular site since local conditions and natural energy resources vary widely from place to place. Large capacity wind generators being developed by ERDA, commercially available solar desalination plants, and solar power systems being developed by both ERDA and industry will probably fall into this category.

Other projects will have been preceded by advanced development where the technology is at a less-developed stage or when special design modification is required to match Navy site requirements.

Demonstration of Photovoltaic System

Objective

The objective is to demonstrate the applicability of a full-scale photovoltaic system at an advanced Navy base.

Technical Approach

Currently available equipment selected on the basis of data and information gathered in the exploratory development program will be built and demonstrated at an advanced base.

FY 1976/77 Progress

This project will begin in FY 1981.

Planned Milestones (Completion Dates)

July 1982—Design, build, and demonstrate full-scale equipment for advanced bases.

Full-Scale Solar Desalination System

Objective

The objective is to test and evaluate a full-scale desalination system at a Navy site.

Technical Approach

The system will be designed based on feasibility studies and analysis under exploratory development work.

FY 1976/77 Progress

This project will begin in FY 1979.

Planned Milestones (Completion Dates)

December 1979—Monitor contract for design of full-scale system.
June 1981—Fabricate and install system.
September 1982—Test and evaluate system.

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U.S. NAVY ENERGY RESEARCH AND DEVELOPMENT PROGRAM PLAN FY 1978---ETC(U)
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Application of ERDA-Developed 1,500-kw Wind Generators

Objective

The objective is to determine the applicability of ERDA-developed 1,500-kw wind generators for bulk power supply at Navy bases, through determination of cost and performance data.

Technical Approach

It is expected that tests of 100-kw ERDA-developed wind generators in the engineering development program will provide data and experience sufficient to plan tests of a 1,500-kw wind generator based on an ERDA design.

FY 1976/77 Progress

This project will begin in FY 1980.

Planned Milestones (Completion Dates)

December 1979–Select a demonstration site for the 1,500-kw NASA/ERDA wind generator test (NWC work request).
June 1981–Prepare contract schedule to procure and install a 1,500-kw wind generator (estimated award date is September 1982).
December 1982–Install 1,500-kw wind generator (by contract).
September 1985–Test 1,500-kw wind generator.

SELF-SUFFICIENCY DOCUMENTATION

4.5 DOCUMENTATION

NAVFAC (Contact: W. Adams–703-325-8535)

"Solar Heating of Buildings and Domestic Hot Water," R-835, E. J. Beck, Jr., and R. L. Field, January 1976, revised April 1976.

"Metal Hydrides for Energy Storage Applications," N-1393, S. C. Garg and A. W. McClaine, June 1975.

"Energy Utilization of Solid Waste at Small Naval Bases–An Economic Decision Model and Comparison of Two Types of Systems," N-1465, P. L. Stone, December 1976.

"Cost-Effectiveness Analysis of Lubricant Reclamation," M-64-76-1, C. W. Anderson, January 1976.

"Data Compilation for Site Characteristics of U.S. Navy Shore Installations FY 76," M-52-76-11, R. E. Bergman, September 1976.

"Operational Testing of a Controlled Air Incinerator with Automatic Ash Handling," CR-77.008, N. Kleinhenz and H. Gregor Rigo, Systems Technology Corporation, November 1976.

"Operational Testing of a System for Solid Waste to Energy Conversion," CR-77.009, H. Kleinhenz and H. Gregor Rigo, Systems Technology Corporation, November 1976.

"Wind Electric Generator Systems–P[illegible]ary Analysis," 63-75-10, R. H. Fashbaugh, November 1974.

"Report on Energy Storage Program," 63[illegible]-8, E. R. Durlak and A. W. McClaine, November 1974.

"Summary of Available Information on Lubricant Recovery and Recycling Equipment, Methods and Techniques," 64-75-11, C. W. Anderson, March 1975.

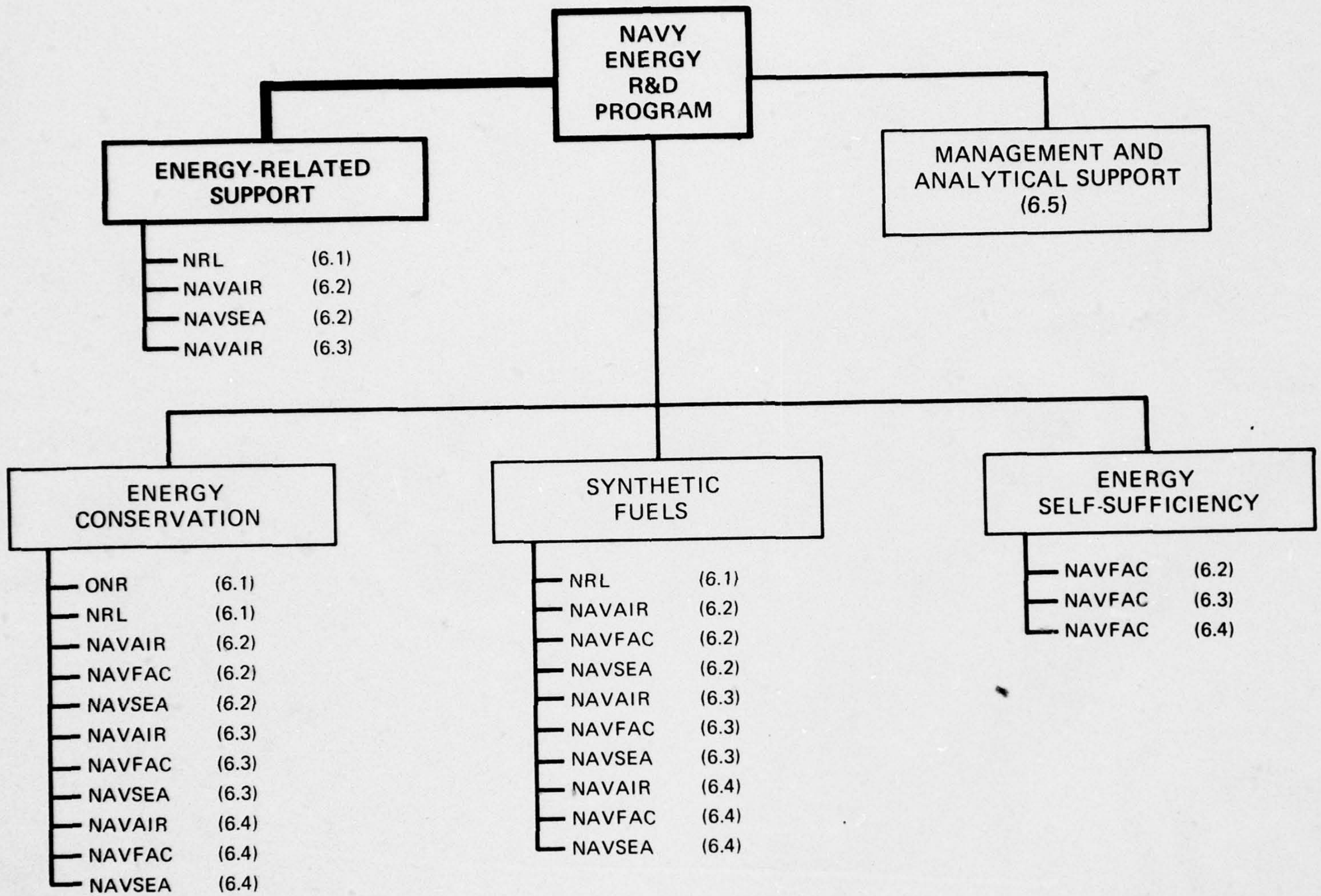
"Equipment and Techniques for Energy Utilization of Solid Waste," 63-75-20, P. L. Stone, April 1975.

"Economic Analysis of Solar Pool Water Heating," 80-76-2, K. F. Vodraska, July 1975.

"Wind Plant Siting Survey," NCW TM-2798, S. E. Lee, April 1976.

"Solar Survey of Selected Navy and Marine Corps Sites," C. E. Parker (CEL letter, 15 June 1976, Ser. 937).

ENERGY-RELATED SUPPORT


NAVY
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NAVAIR (6.2)
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NAVAIR (6.3)
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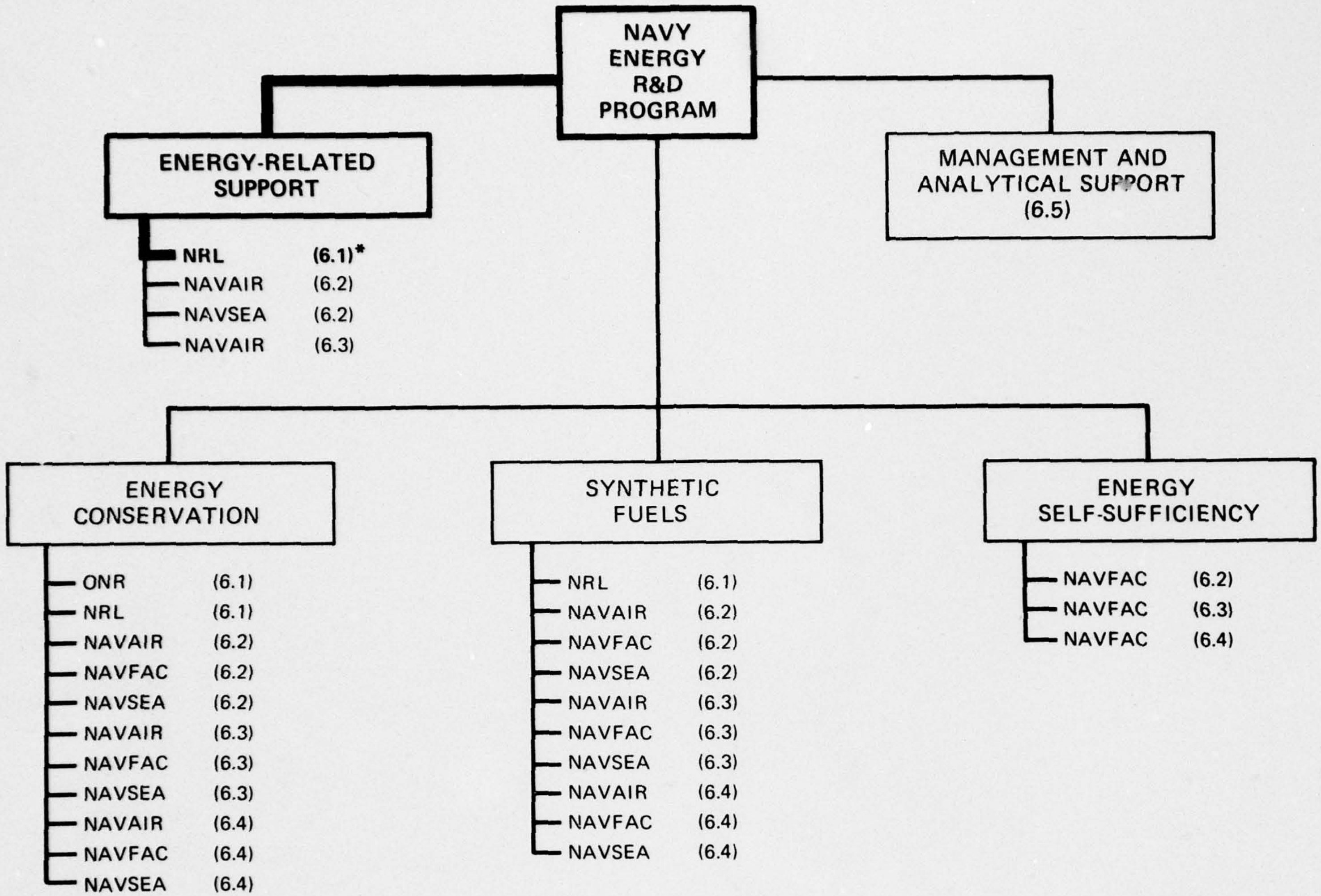
ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
NAVFAC (6.3)
NAVFAC (6.4)

5.0 ENERGY-RELATED SUPPORT

5.1 INTRODUCTION

This section contains a collection of work units that are not managed by MAT-08T3 but relate to energy. The Naval Research Laboratory (NRL) conducts several Category 6.1 efforts in support of fusion technology. NRL's involvement in this area occurs because of the technical capability and physical facilities available at NRL. The fusion power programs are coordinated with ERDA. NAVAIR conducts several Category 6.2 and 6.3 efforts related to improved aircraft propulsion systems. None of these efforts are directly related to any particular energy strategy and are therefore placed by themselves in this section.

ENERGY-RELATED SUPPORT
BASIC RESEARCH (6.1)
NRL



*NOT FUNDED OR MANAGED UNDER THE NAVY ENERGY R&D PROGRAM.

Pulsed Power

P.E. 61153N-11 (NRL)
Task Area RR 011-09-41
Work Unit: HO 2-28.104

Objective

The objctive is to develop techniques for generating impulsive magnetic fields in excess of one megagauss to be used in pulsed power transformers and to provide power for pulsed radiating weapons as well as for adiabatically compressing plasmas to high densities and high temperatures.

Technical Approach

Through preliminary feasibility studies of increasing complexity, and with continued theoretical and engineering support, an experimental configuration is to be constructed in which the implosion of rotating, liquid metal cylinders or liners will be used to compress payloads to high energy density.

The approach is to compress payloads, such as magnetic fields, plasmas, or ion rings, to high energy density by use of stabilized, imploding, conducting cylinders to liners. This technique will be applied to successively larger experiments to obtain compact, multimegajoule pulsed power systems for use in several DOD problem areas, such as particle beam weapons and nuclear weapons simulators.

FY 1976/77 Progress

Experiments with a 540-kilojoule capacitor bank system have been performed. Aluminum liners, initially 28 cm in diameter, 7 cm long and 1 mm thick, have been imploded electromagnetically attaining speeds of 1,400 meters per second. Compressed flux magnetic fields in excess of 1.3 megagauss have been measured in an open area 1 cm in diameter. Initial experiments for pulsed power generation have been performed in which trapped azimuthal magnetic flux is compressed. Rotating liquid metal (sodium-potassium) liners have been imploded electromagnetically to demonstrate rotational stabilization of Rayleigh-Taylor instability. Rotating liquid liners (water) have been imploded with gas-driven pistons to achieve stabilized, reciprocating implosion-expansion operation.

Planned Milestones (Completion Dates)

FY 1977–Study pressure-driven stabilized liquid liners. Design and construct field compressor (LINUS-O).
FY 1978–Design and begin construction of plasma compressor (LINUS-1).
FY 1979–Perform plasma compression experiments with LINUS-1 system.

Energy-Related Support
Category 6.1
NRL

Numerical Simulation and Design of Pulsed Power Experiments

P.E. 61153N-11 (NRL)
Task Area RR 011-09-41
Work Unit: HO 2-28.106

Objective

The objective is to perform theoretical and numerical studies in support of the pulsed power experimental program at NRL.

Technical Approach

Large-scale numerical simulations using fluid codes will be performed to study the dynamics of proposed experiments. Specifically, studies of an imploding conducting blanket to achieve high-magnetic fields will be undertaken. The stability properties of this configuration will be examined. Studies will also be performed on the dynamics of plasma compression in cusp geometries.

FY 1976/77 Progress

One-dimensional calculations of the dynamics of an imploding liner have been performed. Energy input requirements to reach the desired final conditions in this one-dimensional configuration have been determined. Stability properties of the liners have been determined and the beneficial effect of liner rotation has been predicted. Two-dimensional calculations have given preliminary results. Compressibility effects in thick, rotating liquid liners have also been studied. The compression of plasma/field mixtures by imploding liners has also been analyzed.

Planned Milestones (Completion Dates)

FY 1977—Study the one-dimensional dynamic properties of compressible, liquid metal liners.
FY 1977—Perform further analyses of closed-field plasma configurations to be compressed by liners.
FY 1978—Begin design of LINUS-1 plasma compression experiment.
FY 1979—Finalize design of LINUS-1 plasma compression experiment.

Energy-Related Support
Category 6.1
NRL

Cusp Plasma Preheating Experiment

P.E. 61141N (NRL)
Task Area RR 011-09-41
Work Unit: HO 2-28.108

Objective

The objective is to study the creation and containment of a large volume, warm plasma in magnetic cusp geometry. Such a plasma could be subsequently compressed by megagauss magnetic fields as part of the LINUS approach to the creation of high energy density plasmas.

Technical Approach

A large (1-meter diameter) magnetic bottle is created by two oppositely directed magnetic coils (the cusp geometry). Plasma is created by a unique, two-stage process in which a partially ionized gas cloud is created by irradiation of a pellet with a neodymium-glass laser and then fully ionized and heated by a high-power carbon dioxide laser.

FY 1976/77 Progress

Construction of the experiment is complete. The creation of gas clouds by laser irradiation of solid targets has been investigated extensively. The carbon dioxide laser has produced more than one kilojoule, which is absorbed by the gas cloud. Plasma clouds containing over 10^{19} electrons have been created with temperatures of about 50 electron volts.

Planned Milestones (Completion Dates)

FY 1977—Continue experiments of suspended targets.
FY 1977—Study confinement of plasma in cusp system.
FY 1978—Continue experiments on free-falling targets.

Energy-Related Support
Category 6.1
NRL

Research on Mechanisms of Neutron Radiation Damage to Structural Materials

P.E. 61153N-22 (NRL)
Task Area RR 022-09-41
Work Unit: HO 2-28.101

Objective

The objective is to determine performance and develop improved materials for use in advanced high-temperature nuclear systems, such as the liquid-metal fast-breeder reactors, controlled thermonuclear reactors, and gas-cooled reactors through an understanding of the mechanisms of radiation damage, especially void formation and helium embrittlement.

Technical Approach

Accelerated damage production by ion bombardment is used to simulate neutron damage. Correlative in-reactor experiments are conducted. The damage is evaluated by using transmission electron microscopy to characterize the influence of parameters such as irradiation temperature, fluence, flux, microstructure, and solute elements on void formation.

FY 1976/77 Progress

Two nickel-aluminum (Ni-Al) alloys (a 6 percent solid solution alloy and a 15 percent precipitation hardened alloy) have been ion bombarded to 30 displacements per atom (dpa) at 5 temperatures from 525° C to 725° C and at 625° C to fluences of 6, 30, 90, and 200 dpa. Ni-3Al precipitates were found to decrease in size from 230Å to 70Å under irradiation at 725° C. Swelling trends in an Fe-15 Cr-25Ni alloy under study in an ERDA-sponsored intercomparison program were characterized for test matrix points at 600° C, 650° C, 700° C, and 750° C at fluences of 10, 30, 50, and 70 dpa.

Analyses of data on Fe-15 Cr-25 and of the study on Ni-6Al and Ni-14Al alloys were prepared. A parametric study of variables influencing time-dependent nucleation theory was initiated. A report was prepared based on analysis of data from 1 MeV electron irradiations at Harwell. An examination was completed of the influence of preinjection of helium on void nucleation in nickel.

Planned Milestones (Completion Dates)

FY 1977—Continue analysis of neutron irradiated Ni and Ni alloy as specimens are discharged from the reactor.

FY 1977—Continue ion bombardment studies of influence of minor solute additions on swelling of Ni with higher influence irradiations of low-swelling alloys of Ni-1/Si, Ni-1Ti and Ni-1Mo.

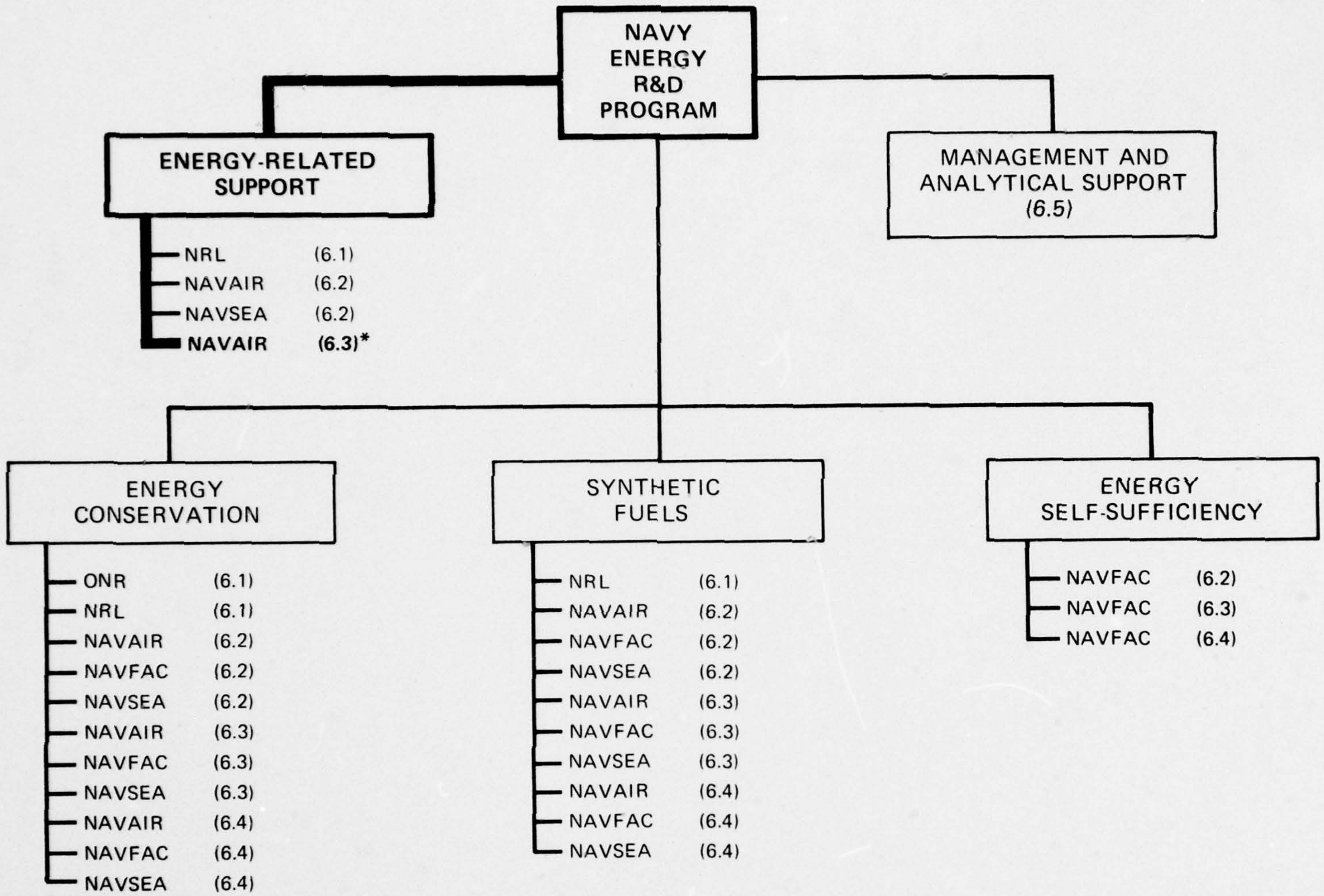
FY 1977–Begin assembly of creep apparatus to study microstructure-property relations in creep and creep rupture.

FY 1978–Prepare treatise on the use of simulation techniques to study and predict swelling in metals.

FY 1978–Continue study of influence of solute additions and precipitates on void nucleation and swelling.

FY 1978–Initiate experiments on influence of microstructure on properties in high temperature alloys for energy conversion systems.

ENERGY-RELATED SUPPORT
ADVANCED DEVELOPMENT (6.3)
NAVAIR



*NOT FUNDED OR MANAGED UNDER THE NAVY ENERGY R&D PROGRAM.

Energy-Related Support
Category 6.3
NAVAIR

Joint Technology Demonstrator Engine

P.E. 63210N (NAVAIR)
Project W0580

Objective

The objective is to take the advanced propulsion system components being developed under "Propulsion Component Technology," W0582, and combine them with advanced components being developed by the Air Force Aircraft Turbine Engine Gas Generator (ATEGG) program into an integrated technology demonstrator engine suitable to support the Navy's planned future aircraft systems development. It will enable demonstration of the systems effects of a whole engine before embarking on an extensive engineering development program.

Technical Approach

The design, fabrication, and assembly of the engines will continue through FY 1977. Contracts were let with two of the three major engine manufacturers to incorporate their components into the joint technology demonstrator engine (JTDE). Support is also being provided to Teledyne-CAE for fan adaptive hardware for their small engine JTDE.

Sea-level tests of JTDEs will be performed in FY 1978 in the manufacturers' test cells. Both steady-state and dynamic testing will be done. The basic design of the JTDE-II will be started.

In FY 1979, altitude tests of JTDE-I will be performed at the Navy Air Propulsion Test Center (NAPTC), Trenton, N.J. The development of JTDE-II will continue.

Planned Milestones (Completion Dates)

June 1975–Award Teledyne-CAE contract.
September 1975–Award GC contract.
January 1976–Award Detroit Diesel Allison Division contract.
July 1978–Initiate JTDE-I development.
December 1979–Complete JTDE-I development.
July 1978–Initiate JTDE-II development.
May 1982–Complete JTDE development.

Propulsion Component Technology

P.E. 63210N (NAVAIR)
Project W0580

Objective

The objective is to provide component technology suitable for operation of all propulsion systems.

Technical Approach

The technology that results from this effort will be a direct part and will be used in the implementation of the Joint Navy/Air Force Turbine engine development plan. As this technology becomes applicable, it will be incorporated into the Joint Technology Demonstrator Engine (JDTE) program (W0580). The initial endeavors will be directed towards variable area high-work load turbines for operation at temperatures up to 3500° F, as well as combustors capable of a 60 percent greater heat release rate.

The development of low-pressure turbines will be completed. The program to develop an advanced high-pressure turbine has been started. The project will partially support the development of the full authority digital electronic fuel control (FADEC) and the directionally solidified eutectic turbine blades. A joint program with NASA will be performed on the interface of two-dimensional nozzles with advanced air frames.

The work on the FADEC and the advanced high-pressure turbines (AHPT) programs will be continued. Because of funding constraints, the remaining programs will be eliminated. In FY 1979, the technology assessment program and the lightweight fuel delivery system programs will be started.

Planned Milestones (Completion Dates)

–Complete LP turbine.
–Start development of advanced high-pressure turbine.
–Accomplish swirl after burner development.
–Develop lightweight fuel delivery system (LWFDS).
–Start inlet/exhaust systems program.

Self-Sufficient Starting System

P.E. 63210N (NAVAIR)
Project W0581

Objective

The objective is to develop a self-sufficient starting system that will make naval aircraft completely independent of government-supplied fuel for engine starting. This includes single or multiple engines, preflight checkout (electrical, hydraulic, and pneumatic), and aircraft standby operation. The system will also provide emergency in-flight power for aircraft control and high altitude engine starting.

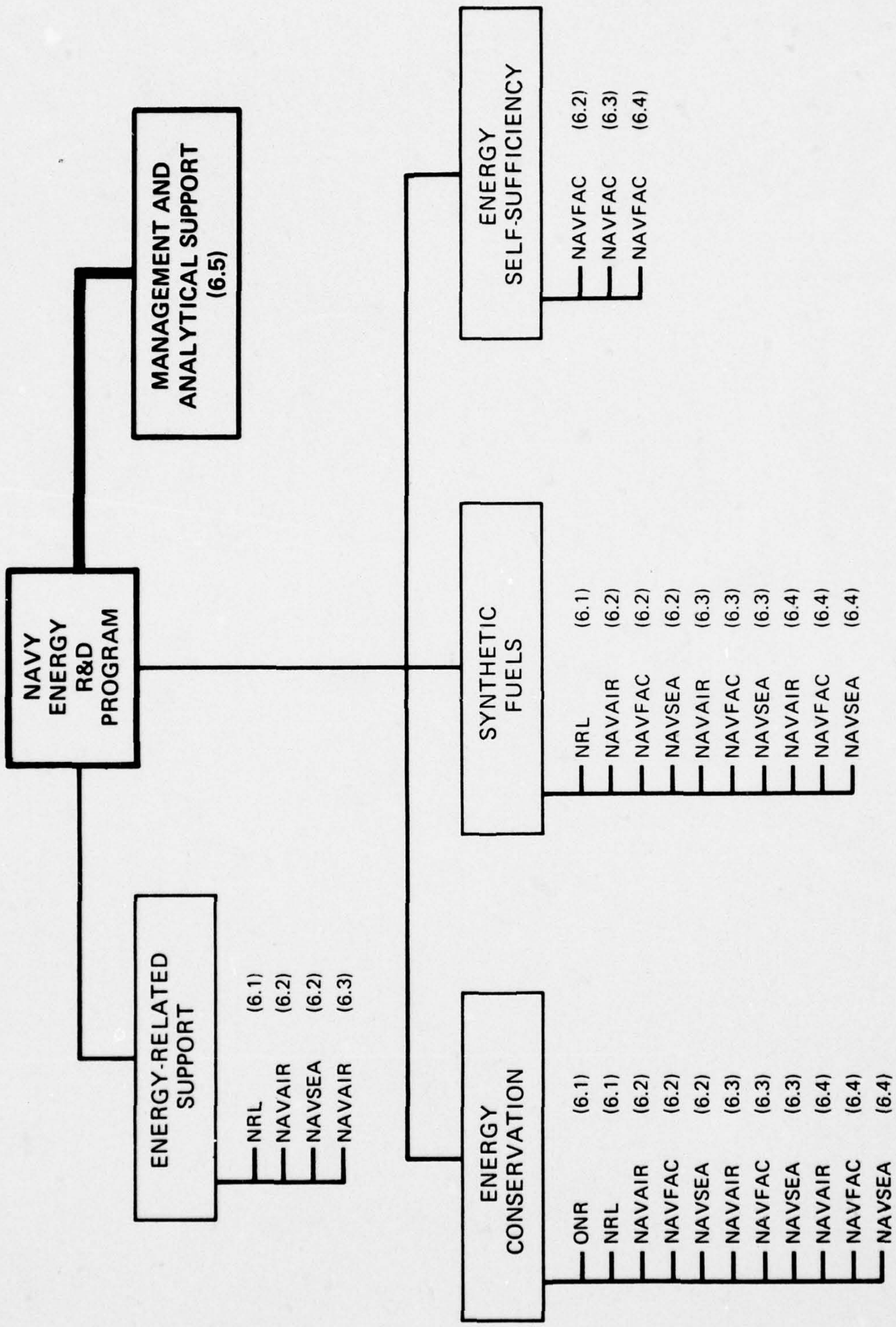
Technical Approach

The proposed system will consist of an advanced design gas turbine auxiliary power unit (APU) with an integrated emergency power supply system and accessory drive gear box equipped with an aircraft flight control hydraulic pump, utility hydraulic pump, and electric power generator. For preflight checkout and standby operation, the APU provides aircraft bleed air and power for gear box motoring to provide aircraft electrical and hydraulic power. The APU drives the engine through a power-take-off shaft for starting.

Planned Milestones (Completion Dates)

October 1977—Initiate development.
November 1978—Initiate testing.
June 1980—Complete development.

ENERGY MANAGEMENT AND ANALYTICAL SUPPORT


NAVY ENERGY R&D PROGRAM
MANAGEMENT AND ANALYTICAL SUPPORT (6.5)
ENERGY-RELATED SUPPORT
NRL (6.1)
NAVAIR (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
ENERGY CONSERVATION
ONR (6.1)
NRL (6.1)
NAVAIR (6.2)
NAVFAC (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
NAVFAC (6.3)
NAVSEA (6.3)
NAVAIR (6.4)
NAVFAC (6.4)
NAVSEA (6.4)
SYNTHETIC FUELS
NRL (6.1)
NAVAIR (6.2)
NAVFAC (6.2)
NAVSEA (6.2)
NAVAIR (6.3)
NAVFAC (6.3)
NAVSEA (6.3)
NAVAIR (6.4)
NAVFAC (6.4)
NAVSEA (6.4)
ENERGY SELF-SUFFICIENCY
NAVFAC (6.2)
NAVFAC (6.3)
NAVFAC (6.4)

6.0 ENERGY MANAGEMENT AND ANALYTICAL SUPPORT (6.5)

These projects encompass Navy in-house management of the energy R&D program and includes analyses and studies necessary for this management. Analyses and studies are assigned by MAT-08T3 to Navy laboratories and contractors.

Navy Energy Usage Profile Study

Objective

The objective is to provide for the maintenance, update, and report preparation for a computer-assisted tabulation and analysis of Navy energy usage, including the ship, air, and shore establishments. Navy energy requirements will be projected to FY 2000, as will the energy needs of specific task force structures, as desired.

Technical Approach

The tabulation will be based on available documentation down to individual Navy units and will include activity level information. It will provide a measure of the impact of conservation and energy-management efforts and policies on energy consumption and level of activity.

FY 1976/77 Progress

The computer program has been completed. The full automated program provided FY 1973-76 historical data and recomputed fuel usage rates. The data were analyzed on a gross summary level and the detailed analysis is under way.

Planned Milestones (Completion Dates)

September 1977—Publish detailed FY 1973-76 analysis.
October 1978—Compile usage profile data for FY 1973-77. Update FY 2000 projection.

Navy Critical Materials Study

Objective

The objectives are to develop the means to monitor critical material usage in naval systems; assess the impact of material shortages, embargoes, etc.; and enable forecasts of material requirements.

Technical Approach

Data sources and the specifications or standards governing their content are being reviewed to identify data available and the format. The use of the data sources is then examined and a "unified" specification is proposed that will meet all users' requirements and be in a format suitable for automatic data processing. The computer program to convert the raw data, in unified format, into the material usage data is being developed in parallel.

To prove the workability of the program and the unified specification format, manual compilations will be made on typical naval items. These results will be compared with the results of the program.

FY 1976/77 Progress

A report was issued on the development of the methodology, including a manual compilation of data for a Worthington Type JDE auxiliary steam turbine. A contract was issued to review existing data sources, propose a unified specification, and develop an automatic data processing program. The feasibility is to be demonstrated on the LM-2500 gas turbine.

A preliminary report on the data source review was issued.

Planned Milestones (Completion Dates)

January 1977—Begin review of unified specification by various agencies.
January 1977—Review results of manual compilation.
April 1977—Recast data for LM-2500 into proposed unified format and run trial.
July 1977—Complete report on program, comparing program results with the manual results.
September 1977—Complete manual compilation of piece parts for LM-2500.
November 1977—Update material element reference file.
December 1977—Review existing data sources and recommend unified specification.
July 1978—Complete review of unified specification by user agency.

July 1979—Adopt unified specification and make part of all Navy contracts.
January 1980—Begin to review input, based on unified specification, and use program.
January 1985—Based on usage data, forecast material requirements.

Technical Assistance to Navy Energy R&D Office

Objective

The objective is to provide a weekly situation report, an annual energy fact book, assistance in annually updating the Energy R&D Plan, an annual report of energy R&D progress, and technical concept reviews, evaluations, reports, and visual aids as required.

Technical Approach

Technical assistance in providing the above items is accomplished by contractors and Navy laboratory support.

FY 1976/77 Progress

Technical support provided in FY 1976 and 1977 has included:

- Comprehensive assessments of national and worldwide energy resource data, policy issues, and energy R&D programs. Results of this effort were reported in weekly situation reports (SITREP) and in two issues of the Energy Fact Book.
- Preparation of input data and conduct of studies and analyses in support of Navy energy R&D planning documents. A draft Energy R&D Program Plan for Navy staff and working level review was distributed in July 1976, followed by publication of the final version of the plan in October 1976. A minor update to the Plan was distributed in April 1977, followed by a complete draft rewrite for staff and working level review in July 1977.
- Preparation and publication of Navy Energy R&D Progress Reports in January, March, and November 1976, and in April 1977.
- Research and preparation of "Assessment of NASA Aircraft Fuel Conservation Technology Task Force Report and Related Congressional Testimony," "Assessment of ERDA/DOI Environmental Impact Statement for Proposed Synthetic Fuels Commercialization Program," "Comments on Feasibility of Supplying Geothermal Energy to the Naval Station, Keflavik," "Preliminary Assessment of Tidal Power Potential at Cutler, Maine," "Assessment of the State of the Art of Converting Wind Energy by the Windmill Mode to Electrical Energy," and "Technical Assessment of IGT Process for the Improved Conversion of Oil Shale to Hydrocarbon Fuels."
- Numerous point papers and other reports were prepared, including analysis of the impact of legislative action; comments and recommendations on ERDA Plan 76-1; draft "Memorandum of Understanding for Joint Energy Efforts of ERDA/DOD"; comments on draft DETG Phase III Report; "Evaluation of Advanced System Concept: Navy Modular Integrated Utility System"; strategies in the 6.2 Program,

"Fuel Chemistry"; review of ERDA conservation program approval document; Navy Decision Coordinating Papers on synthetic fuels, energy conservation, and self-sufficiency; and "Navy Energy R&D Summary."

Planned Milestones (Completion Dates)

Weekly—Publish SITREP.
Bimonthly—Update Energy Fact Book chapter by chapter.
1 October 1977—Publish Navy Energy R&D Program Plan.
1 January 1978—Update R&D Program Plan.
1 April 1978—Update R&D Program Plan.
1 April 1978—Prepare annual Navy energy R&D progress report.
1 July 1978—Rewrite Energy R&D Program Plan.
As Requested—Prepare technical concept assessments and technical reports.

Energy Usage Statistics for Sewells Point

Objective

The objective is to determine the site characteristics of Sewells Point Navy Base to characterize energy usage.

Technical Approach

The Sewells Point Navy Base will be analyzed to identify end uses of energy on an atypical multifunctional Navy base.

FY 1976/77 Progress

This project will begin in FY 1978.

Planned Milestones (Completion Dates)

Milestones for this project are yet to be determined.

Energy Management and
Analytical Support
Category 6.5
NAVFAC

Review of Guidance Governing Centralized Steam and Electric Power Generation by Naval Installations

Objective

The objective is to review Navy policy governing central steam and electric power generation in light of current fuel costs and projected escalation.

Technical Approach

The industrial and commercial guidance established by the Navy governing centralized steam and electrical power generation by naval installations should be reviewed in light of present day fuel costs and projected escalation. The study involves two major areas of concentration: centralized steam generation compared with replacement of many small existing boilers, and continued purchase of electric power versus central generation at a Navy base. Since the Navy is actively attempting to convert from oil and natural gas to coal, this study should be based on a conventional pulverized coal unit with both particulate and sulfur dioxide control.

FY 1976/77 Progress

A contract statement-of-work for the study was prepared. The work will be done in three phases. Phase I, covering existing boilers and steam-turbine generators, will involve a general study of on-base electric power and steam generation and a site-specific analysis at two shipyards. Phase II will include preparation of preliminary designs and parametric analyses of system performance and cost for both new central and decentralized steam plants with flue gas desulfurization. Phase III calls for cost-effectiveness studies to determine if electric power should be generated in addition to heat and process steam at new central plants. Only Phase I will be done in FY 1977.

Planned Milestones (Completion Dates)

December 1976—Prepare contract schedule for guidance study.
July 1977—Award contract for Phase I.
November 1978—Award contract for Phase II.
November 1979—Award contract for Phase III.
July 1977-September 1980—Monitor contract and publish reports.

7.0 FUNDING

Various funding profiles have been prepared to show the Navy energy R&D program funding situation. These funding data are tabulated in two ways. The funds required to conduct the work planned in this document are shown in Table B-2. Funds authorized by POM-79 are shown in Table B-3, and are identical to the previously approved FYDP.

Table B-2. REQUIRED FUNDS BY CATEGORY AND STRATEGY, FY 1978-83
(Millions of dollars)

Category	Strategy	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983
6.3	Energy Conservation	2.1	6.2	10.7	14.2	16.1	18.5
	Synthetic Fuels	5.5	9.5	12.2	14.9	16.7	18.4
	Energy Self-Sufficiency	1.9	6.6	9.1	8.7	10.0	11.2
	Subtotal	9.5	22.3	32.0	37.8	42.8	48.1
6.4	Energy Conservation	4.5	7.7	13.2	16.9	23.8	29.9
	Synthetic Fuels (T&E)	0.5	2.0	3.0	3.8	7.0	11.0
	Energy Self-Sufficiency	0	2.1	3.9	7.0	9.1	15.1
	Subtotal	5.0	11.8	20.1	27.7	39.9	56.0
6.5	Energy Management and Analytical Support	1.1	1.4	1.7	2.0	2.0	2.0
Total	Energy Conservation	6.6	13.9	23.9	31.1	39.9	48.4
	Synthetic Fuels	6.0	11.5	15.2	18.7	23.7	29.4
	Energy Self-Sufficiency	1.9	8.7	13.0	15.7	19.1	26.3
	Energy Management and Analytical Support	1.1	1.4	1.7	2.0	2.0	2.0
	Total	15.6	35.5	53.8	67.5	84.7	106.1

Table B-3. POM-79 FUNDING BY PROJECT, FY 1977-83
(Millions of dollars)

Program Element Number	Project Number	Strategy	FY 1977	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983
62765N		All	4.9	5.4	5.9	6.2	6.8	7.5	8.3
63724N	Z0829	Energy Conservation	0.7	2.1	2.4	3.5	4.9	5.9	
63724N	Z0838	Synthetic Fuels	4.5	3.9	4.3	7.9	13.8	15.9	
63724N	Z0840	Energy Self-Sufficiency	0.6	1.5	2.1	3.8	6.8	8.0	
		Subtotal	5.8	7.5	8.8	15.2	25.5	29.8	29.8
64710N	Z0371	Energy Conservation	2.3	3.0	3.8	5.6	8.0	8.7	
64710N	Z0347	Synthetic Fuels (T&E)	–	–	–	1.1	1.1	1.6	
64710N	Z0350	Energy Self-Sufficiency	1.5	–	–	0.5	1.1	1.6	
		Subtotal	3.8	3.0	3.8	7.2	10.2	11.9	11.9
65861N	Z0362	Energy Management and Analytical Support	0.5	1.1	1.4	1.7	2.0	2.0	2.0
		Total	15.0	17.0	19.9	30.2	44.5	51.2	52.0

APPENDIX C

NATIONAL ENERGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAMS

1.0 INTRODUCTION

Establishment of the Department of Energy (DOE) on 1 October 1977 brought with it significant changes in the structure of federal energy research and development functions. Consolidation of the Energy Research and Development Administration (ERDA), the Federal Energy Administration (FEA), and the Federal Power Commission (FPC), in addition to the transfer of responsibilities from other agencies and departments, provides a new structure for the formulation and implementation of energy policy. The impact of this reorganization on research and development is uncertain, but a White House Fact Sheet, released 1 March 1977, set forth President Carter's philosophy of what the new role of energy research and development should be in DOE: "An energy research and development program should exist not to serve its own ends, but to provide the country with the energy options which national priorities demand in order to balance our energy needs."

The DOE Organization Act (P.L. 95-91) was signed 4 August 1977. The Act provided for a Secretary, a Deputy Secretary, an Under Secretary for Energy Conservation, and eight Assistant Secretaries. Eleven responsibilities are to be divided among the eight Assistant Secretaries. The 11 areas are: energy resource application, energy research and development, environmental concerns, international programs and policies, national security functions, intergovernmental policies and relations, competition and consumer affairs, nuclear waste management, energy conservation programs, power marketing regulation, and public and congressional liaison. The President, upon appointment of the various Assistant Secretaries, is to identify the particular functions assigned to each. These 11 areas represent programmatic responsibilities that were once assigned to agencies and departments absorbed or partially transferred to DOE. Figures C-1 and C-2 provide a graphic summary of the responsibilities assumed by DOE and the organization of the new department.

To accommodate the functions that are outside the responsibilities of the Assistant Secretaries, the Act provides for the establishment of an Energy Information Administration, a Federal Energy Regulatory Commission, an Office of Energy Research, an Economic Regulatory Administration, and a Leasing Liaison Committee.

The Energy Information Administration is responsible for a centralized energy data and information program to collect, evaluate, assemble, analyze, and disseminate data and information. The areas of concern are energy resource reserves; energy production, demand, and technology; and related economic and statistical information.

The Federal Energy Regulatory Commission is a five-member independent regulatory commission with responsibility for regulatory functions transferred from FPC, FEA, and

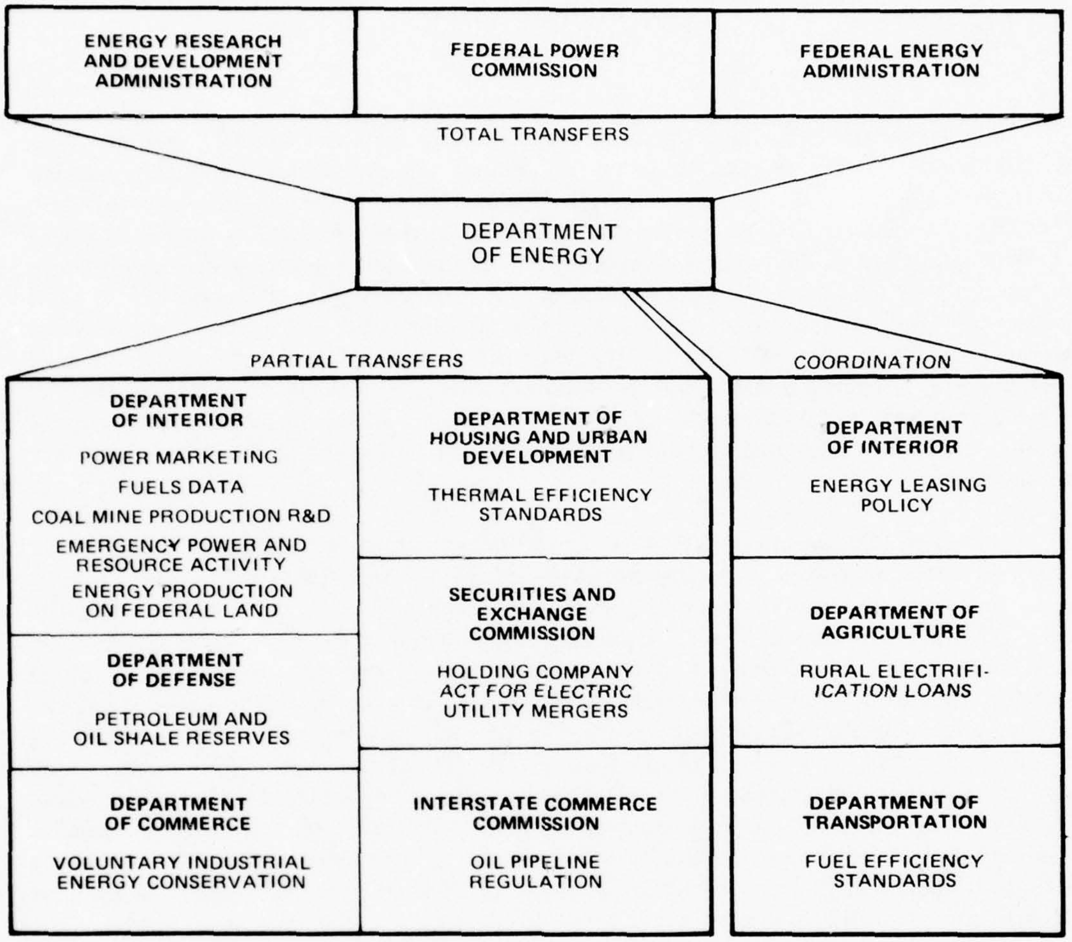


Figure C-1. FUNCTIONS AND AUTHORITIES TRANSFERRED TO DEPARTMENT OF ENERGY

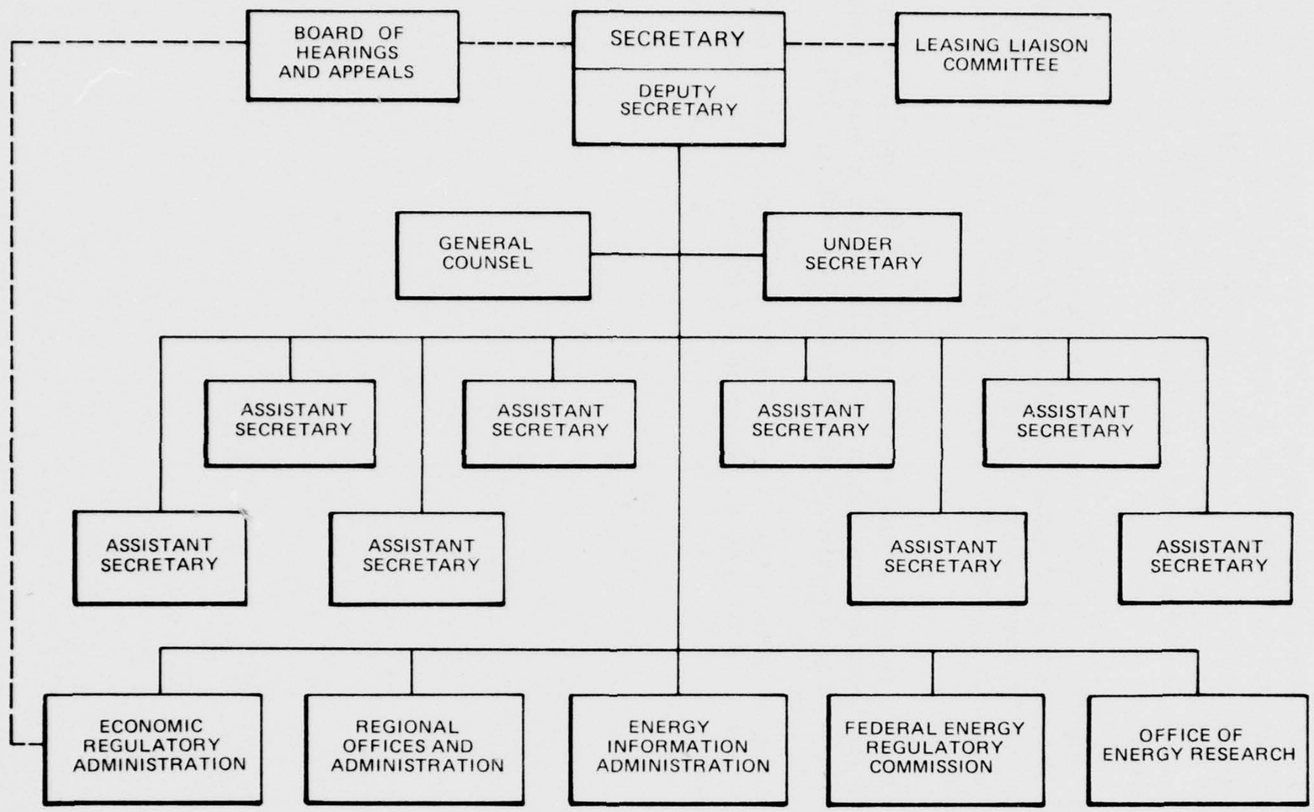


Figure C-2. ORGANIZATION OF DEPARTMENT OF ENERGY

the Interstate Commerce Commission (ICC). This includes pricing and licensing for a wide range of energy sources.

The Office of Energy Research has assumed ERDA's physical research program and is involved in identifying gaps and duplications in research and development, managing laboratories supporting the nuclear weapons complex, promoting education and training in basic and applied research, and carrying out additional assigned duties supportive of basic and applied research. The Office also serves as the principal adviser to the Secretary on energy research issues.

The Economic Regulatory Administration is required by the Act to maintain separate offices for the preparation of regulations and the enforcement of those regulations. The Secretary has the responsibility of determining the functions of the Administration with the stipulation that they not overlap the duties of the Federal Energy Regulatory Commission.

The Leasing Liaison Committee's function is to coordinate the separate responsibilities of DOE and the Department of Interior (DOI) as they relate to energy leasing. The Committee comprises an equal number of representatives from DOE and DOI.

Before the creation of DOE, energy-related programs were diffused among several agencies and departments. A review of these agencies and departments and how DOE has affected them follows.

2.0 ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION (ERDA)

ERDA was established by the Energy Reorganization Act of 1974 (P.L. 93-438) to unite the major federal activities in energy research and development and to coordinate the development of all energy sources.

As of 1 October 1977, all of ERDA's plans, programs, and interagency agreements were assumed by DOE. (Figure C-3 shows ERDA's organization before the transfer.) A review of ERDA's programmatic contribution to DOE follows.

Soon after its establishment, ERDA, in compliance with its legislative mandate, began to determine the requirements for the development of a national plan for energy research, development, and demonstration (RD&D). Using the policy goals established by Project Independence, ERDA set national technology goals. ERDA's RD&D program, as stated in ERDA 77-1, has taken a new, more directed approach in accordance with President Carter's national energy plan submitted to the Congress on 20 April 1977. The impetus of this plan is toward energy conservation and the development of new fuels. It calls for (1) a conservation program to improve the efficiency of energy use and to reduce increased demand, (2) expansion of existing fuel sources through enhanced recovery techniques and conversion of industries and utilities using oil and gas to coal and other more abundant fuels, and (3) development of new fuels that are renewable and inexhaustible.

Table C-1 outlines ERDA's FY 1978 budget request and approved appropriations for its fossil energy program. The total budget for ERDA energy programs has changed significantly since FY 1976, the first full year ERDA budget, in terms of dollar amount and program emphasis and distribution. Table C-2 reflects these budget trends.

The areas of emphasis in the FY 1978 budget request are:

- Conservation, to greatly expand the program to develop or improve technology for energy conservation in transportation, residential/commercial buildings, and industry, and thus reduce imports of foreign oil and gas, and to conduct RD&D for the recovery and utilization of waste heat at ERDA's enrichment plants and production reactors, in accordance with the national energy plan.
- Fossil Energy, to substitute coal and coal-derived fuels for oil and gas; to expand existing technology to develop economic and environmentally safe methods to burn coal directly, particularly the high-sulfur, eastern coals; and to develop enhanced recovery techniques for petroleum and shale oil.
- Solar Energy, to continue the solar heating and cooling demonstration program as well as further R&D; to support and expand solar electric R&D programs and the

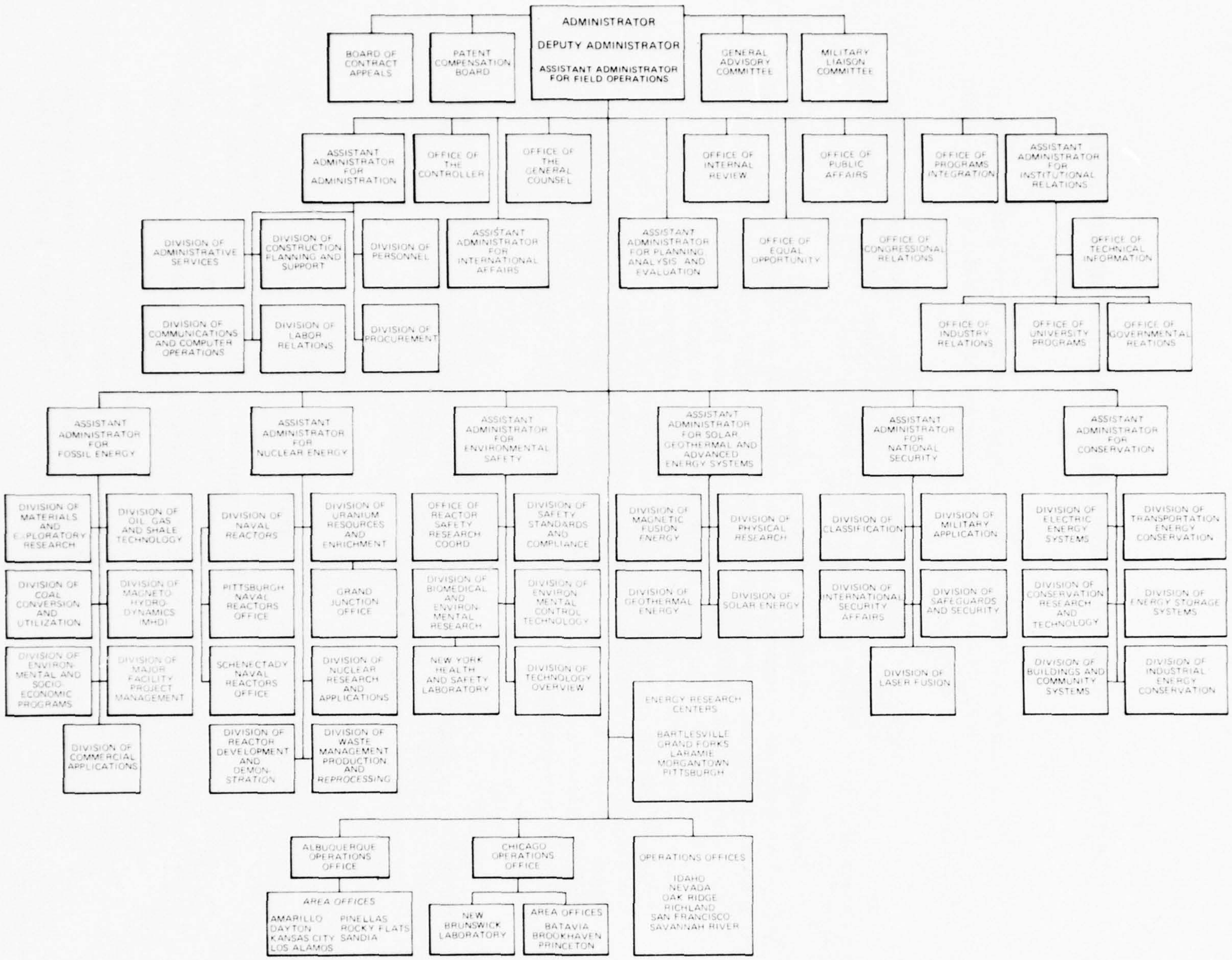


Figure C-3. ORGANIZATION OF ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Table C-1. ERDA FOSSIL ENERGY DEVELOPMENT/ OPERATING EXPENSES
(Budget authority, millions of dollars)

Program	ERDA Revised Budget Request	FY 1978 Appropriations
Coal		
Coal liquefaction	107.0	81.1
High-Btu gasification	51.2	59.3
Low-Btu gasification	73.9	50.0
Advanced power system	25.5	12.8
Direct combustion	53.2	55.1
Advanced research and supporting technology	40.0	38.5
Demonstration plants	50.9	50.6
Magnetohydrodynamics	45.8	27.8
Total coal	447.5	375.2
Petroleum and Natural Gas		
Natural gas and oil extraction	73.1	35.2
Support research	3.0	1.8
Total petroleum and natural gas	76.1	37.0
In-Situ Technology		
Oil shale	28.0	13.3
Coal gasification	11.0	13.5
Total in-situ technology	39.0	26.8
Total FY 1978 fossil energy operating expenses	562.6	439.0

Table C-2. FUNDING TRENDS IN ERDA PROGRAMS
(Budget authority, millions of dollars)

Program	FY 1977	FY 1978	Change (Percent)
Conservation	161	309	92
Fossil energy	483	621	29
Solar energy	290	368	27
Solar heating and cooling		96	
Solar electric and other		272	
Geothermal	55	116	111
Fusion	428	455	9
Fuel cycle R&D	185	350	89
Fission power reactor development	788	690	-12
Breeder reactor	639	456	-29
Other	149	234	57
Environmental R&D	274	300	9
Total	2,664	3,209	20

agricultural and industrial use of process heat and biomass; and to expand the photovoltaic systems program to develop a less expensive solar cell.

- Geothermal Energy, to expand knowledge of the magnitude and content of geothermal reservoirs as well as utilization of the resource through a federal loan guarantee program; to begin work on a 50-Mw geothermal power demonstration facility; and to characterize geopressured resources and nonelectric applications of geothermal energy.
- Fusion Power, to exploit recent breakthroughs and continue research to determine the scientific feasibility of obtaining unlimited fusion power for the long term; to continue work on magnetic confinement and construction alternatives of the Tokamak Test Reactor at Princeton, New Jersey; and to expand the inertial confinement research program.

2.1 ENERGY CONSERVATION RESEARCH AND DEVELOPMENT

In FY 1978, energy conservation research and development plays a significantly larger role than in past years. Energy conservation not only means reduction of energy usage but includes more efficient equipment and buildings, and for the long term, the development of new, energy-efficient technologies. In the near-term energy conservation measures will help to eliminate the waste of energy in systems, thus providing the necessary time to expand the use of existing fuels and to develop new fuel sources and energy-use patterns.

The primary energy end-use sectors are transportation, residential/commercial, and industrial. Energy conservation R&D technologies will help to provide many effective conservation alternatives.

2.1.1 Transportation

Passenger vehicles consumed almost half of the domestic energy used by the transportation sector in 1976 (26 percent of total domestic energy). For this reason, conservation measures are directed at achieving a reduction in petroleum consumption through smaller, lighter cars and modifications to the internal combustion engine.

The turbine and Stirling engine systems, based on continuous combustion processes, are being developed to provide fuel economy and clean air. After further development, it is estimated that the turbine engine will be 50 percent more efficient than conventional engines. The development of the Stirling cycle is not as advanced as the turbine, but after the problems of an automotive version have been resolved, fuel efficiency could improve by 50 to 60 percent.

ERDA is also involved in the development of electric and hybrid automobiles. Public Law 94-413, the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, calls for the demonstration of the potential of these automobiles and the implementation of a loan guarantee program to encourage commercial production of electric and hybrid vehicles.

Other modes of transportation—trucks, airplanes, trains, and ships—are also being studied for improved energy conversion efficiency methods.

2.1.2 Residential/Commercial Buildings

The residential/commercial sector consumed 37 percent of total domestic energy. Most of this energy went into heating, ventilating, and air conditioning of buildings. For this reason, development of gas-fired heat pumps and other economic, energy-efficient systems are being accelerated. Retrofit applications to heat pumps, as well as insulation of buildings, will be used until new systems are developed.

2.1.3 Industry

Until recently, energy consumed by the industrial sector has been inexpensive and plentiful; therefore, there has been no incentive to develop ways to reduce the wasteful use of energy. Since the industrial sector is a large consumer of energy, conserving waste will help to expand fuel efficiency. ERDA has divided its energy conservation RD&D program for the industrial sector into two major areas of action. One area is directed at the six industries that consume 70 percent of all industrial energy—steel, glass, chemicals/petroleum, pulp and paper, cement, and food processing. The second area includes all other industries.

Since energy inefficiency is so prevalent in industry, ERDA is working toward the development of waste-heat recovery systems. One system that converts waste heat from diesel- or gas-turbine systems into mechanical and electrical energy is the organic Rankine bottoming cycle. To demonstrate the energy efficiency of the Rankine cycle, five 600-kw units will be tested in selected industrial plants.

Studies are also being conducted in the industrial energy conservation RD&D program to recover waste heat in uranium enrichment and gaseous diffusion plants.

2.2 EXPANSION OF EXISTING FUEL SOURCES

To meet energy demand until new fuel sources can be developed, existing fuel sources must be expanded. To do this, the national energy plan calls for development of enhanced oil and natural gas recovery techniques, an increase in the direct use of abundant coal, and an increased use of light water reactors. These have also been the major goals of ERDA's RD&D program.

ERDA is working with industry to develop and test enhanced oil recovery techniques to obtain petroleum that is still in the ground after conventional removal is completed. Nineteen test projects are planned with various industrial plants using five recovery techniques already developed. Techniques to extract more natural gas than is possible using conventional techniques are also being developed. Along with the continued development of new techniques, 18 enhanced natural gas recovery projects will be jointly funded by the government and industry.

Coal is the most abundant energy resource in the United States and, therefore, is the prime substitution resource for petroleum and natural gas. However, new technologies must be developed to make the use of coal attractive to industries and utilities. Economical methods must be developed to burn coal directly while controlling the emission of pollutants into the environment.

The R&D program for coal conversion emphasizes:

- Beneficiation–Cleaning the coal before combustion to remove impurities.
- Atmospheric Fluidized-Bed Combustion–Mixing the coal with limestone to eliminate sulfur pollutants and burning the coal in a fluidized bed. This new method of coal combustion is efficient and environmentally safe. This technology is being demonstrated on a 30-Mw steam boiler in Rivesville, West Virginia. Larger industrial applications are being planned.
- Low-Btu Coal Gasification–Burning coal in limited amounts of air to produce gas with a low energy content. This method permits direct on-site use of the gaseous fuel as a clean burning fuel or chemical feedstock. Demonstration units to test these various applications are planned. For the longer term, advanced techniques to develop high-Btu gas and synthetic crude oil from coal are being developed.

ERDA's R&D on light water reactors with once-through fuel cycles involves a search for an environmentally acceptable and economical safeguards system to ensure peaceful uses of nuclear material. These safeguards systems are designed to account for uranium, and more recently thorium, materials, from locating and mining through the nuclear power system to radioactive waste management.

2.3 DEVELOPMENT OF NEW FUELS AND TECHNOLOGY

While the supply of fuel is being increased through conservation and increased use of more abundant resources, RD&D is progressing on new technologies to use new fuels–shale oil, synthetic fuels from waste and biomass, geothermal heat, and solar energy. Some of these energy systems are being studied for use in 1985-2000. Renewable or "inexhaustible" resources–solar electric, hot dry rock geothermal, and fusion–are being studied for use after 2000.

The midterm RD&D program provides for:

- Pilot plants to demonstrate shale oil technologies.
- Federal loan guarantees to make more capital available to industry to develop geothermal resources.
- Demonstration of solar heating in residential, commercial, industrial, and agricultural situations. Collectors, storage and heat exchanger units, and heat pumps and air conditioners are also being developed.
- Economic conversion of waste and biomass into fuels without harmful environmental effects.

The following energy technologies are being developed for the long term.

2.3.1 Solar-Electric Power

Solar-electric systems are a major part of the ERDA RD&D program to develop renewable energy resources. Technologies relating to photovoltaic cells, thermal, wind, and ocean conversion are all being pursued. ERDA has been involved in efforts to increase the marketability of photovoltaic cells by reducing the peak watt cost to $0.50. Cost reductions are also sought in the thermal electric conversion system. Thermal test facilities of 5- and 10-Mw capacity are being built in New Mexico and California, respectively. A 100-kw wind energy conversion system has been tested over the last year; the major problem is to make the system economically competitive with conventional systems. Other wind energy conversion machines being built or designed are two 200-kw systems and a 1.5-Mw system. Development of ocean thermal electric conversion systems are not as advanced but programs for testing the components of heat exchangers and biofouling control technologies are beginning.

2.3.2 Advanced Reactor Systems

The United States has reevaluated and decreased the emphasis on its advanced nuclear reactor R&D program because of the danger of proliferation. The fate of the Clinch River demonstration liquid metal fast breeder reactor is still uncertain; the Hanford fast flux test reactor will be completed and operating by 1980. While other breeder and converter reactors will be developed for improved performance and fuel supply, the major emphasis will be nonproliferation and safeguards systems.

2.3.3 Fusion

The fusion technology program uses abundant, low-cost deuterium and tritium (DT) to develop electric power reactors that are commercially feasible. To achieve this, ERDA has been studying two methods of fusion to produce thermonuclear energy. The magnetic confinement method confines and heats a DT "plasma" until the high velocity nuclei fuse on collision. An experimental Tokamak test facility is being constructed at Princeton, New Jersey. Further studies will be conducted on the fusion plasma technology to obtain the knowledge necessary to predict thermonuclear plasma behavior in confinement systems and fusion power reactors.

Inertial confinement technology implodes pellets of DT by using laser, electron- and ion-beam sources. As a result, the nuclei fuse and release energy. A demonstration laser facility in the 1980s will further explore inertial confinement technology and the feasibility of obtaining unlimited fusion power for the long term.

2.4 SUPPORT TECHNOLOGIES

2.4.1 Basic Energy Sciences

The objective of the basic energy sciences program is to develop a scientific *understanding of physical phenomena* basic to the energy technologies of all ERDA programs. Research in the basic energy sciences program is conducted in three areas: nuclear sciences; material sciences; and molecular, mathematical, and geosciences. The work is focused on scientific areas judged to have the greatest potential impact on energy applications, although in such research it is not always possible to prejudge how or where the results will be applied. The program is designed to develop new experimental and theoretical insights, new concepts, improved instrumentation and other innovations in the key areas for continued progress in energy research, development, and demonstration. The program includes precise experimental determination of data, preparation of specialized materials, and laboratory demonstration of new processes and concepts where such activities are most effectively carried out as part of a program of fundamental research. The priorities are being reordered to place more emphasis on research related to non-nuclear technologies.

2.4.2 Environmental and Safety Research

The goal of the environmental and safety research program is to ensure that energy technologies are environmentally and socially acceptable. Because environmental and safety factors must be considered at all levels of RD&D, ERDA has placed high priority on these factors throughout each energy technology program. Priority is also given to the health and safety of workers and the public to protect them from potentially harmful effects of energy development and use. ERDA programs have also coordinated environmental and safety activities and informed the public and technical/policy decision-makers of energy-related environmental and safety progress and problems. Environmental planning, in accordance with the National Environmental Policy Act (P.L. 91-190), is another major part of the energy technology program at ERDA. Beginning in 1977, environmental development plans have been prepared for all major technology programs. The plans organize the environmental and safety activities of energy technology development as well as identify environmental issues, solution plans, and environmental impact.

2.5 PROGRAM PLANNING STUDIES

The Market-Oriented Program Planning Study assists in budget and program planning in FY 1979 and later by examining the market and determining which technologies will best serve a particular area, when, and at what cost. RD&D lead times and goals can then be established based on this rate of market penetration by various energy technologies.

The Inexhaustible Energy Resources Study (IERS) is an ongoing RD&D strategy for renewable energy resources and technology. The IERS attempts to determine when the need for renewable and inexhaustible resources will arise and what technologies should be used to meet the need.

3.0 FEDERAL ENERGY ADMINISTRATION (FEA)

FEA was established on 7 May 1974 to direct and conduct programs related to the production, conservation, use, control, distribution, and allocation of all forms of energy. These functions, as of 1 October 1977, were transferred to DOE. FEA's statutory program requirements, as described in the following summary, are continuing under the new department.

The Energy Policy and Conservation Act (EPCA), signed 22 December 1975, determines many of FEA's program activities. The EPCA establishes national policies on oil price and allocation controls, conservation measures, supply initiatives, and emergency authority, i.e., contingency planning for protection against another embargo. Specific provisions of the act include:

- Creation of standby authorities that enable the President to use rationing and mandatory conservation plans to meet domestic needs and international energy commitments if an oil supply interruption should occur.
- Creation of a Strategic Petroleum Reserve to offset the impact of a supply cut-off.
- Provision for loan guarantees to develop new underground coal mines.
- Establishment of ceiling prices on domestic oil and incentives to stimulate specific types of oil production.
- Conservation of energy through voluntary and mandatory programs applicable to industry, the population of the United States, and the federal government.
- Establishment of energy-efficiency standards for automobiles and energy-efficiency targets for appliances and other consumer products.
- Expansion of the coal conversion program to reduce the demand for natural gas and petroleum products.

The Energy Conservation and Production Act (ECPA), signed 14 August 1976, extended the life of FEA through 31 December 1977, and established within FEA an Office of Energy Information and Analysis. The ECPA also provided for electric utility rate design initiatives, energy conservation standards in new buildings (provision applies to HUD), and energy conservation assistance for existing buildings and industrial plants.

The ECPA requires FEA to develop and submit to Congress proposals for the improvement of electric utility rate design. The rate designs should reflect marginal cost pricing, encourage economical purchase of fuel, and encourage electric utility system reliability. Funding is provided for demonstration projects to improve load management and rate reform initiatives of electric utilities. Grants are available to the states for the

establishment and operation of consumer affairs offices to facilitate the presentation of consumer interests before utility regulatory commissions.

The Administrator of FEA, under the ECPA, is responsible for providing guidelines, technical expertise, and financial grants to implement energy conservation programs in existing residential and commercial buildings. These financial grant programs would be administered and regulated by the FEA Administrator to weatherize low-income housing and to assist states in the development of state energy conservation plans.

FEA's organization is shown in Figure C-4. Executive Direction and Administration includes the Administrator of FEA and the support services required for the execution of the administrator's responsibilities. These responsibilities include providing advice to the President and Congress relating to the establishment of a national energy policy, working with the Secretary of State on the development of an integrated domestic- and foreign-energy policy, and implementing the resulting programs.

The support services include legal, financial, personnel, grievance, organization management, and procurement functions. Maintaining good rapport with the public, Congress, and state governments is also the responsibility of this division.

The implementation of the FEA programs requires a coordinated effort by six major divisions.

3.1 ENERGY INFORMATION AND ANALYSIS (EI&A)

The EI&A office forecasts short- and long-range energy supply and demand. Economic analyses of these statistical studies are also provided by the EI&A office. Because of the data collection, processing, and automatic data processing systems design functions of the National Energy Information Center (NEIS) within this office, it is the national energy data clearinghouse for FEA, state and federal government agencies, Congress, and the public.

3.2 ENERGY REGULATORY PROGRAMS

This division monitors the compliance with existing regulations and the regulations made law by the Emergency Petroleum Allocation Act by audit and enforcement powers. Information gathered enables the review, development, and updating of the national energy contingency plans on an ongoing basis.

3.3 ENERGY CONSERVATION AND ENVIRONMENT

The Office of Energy Conservation and Environment has three goals:

- Reduce the energy demand growth rate in the United States.

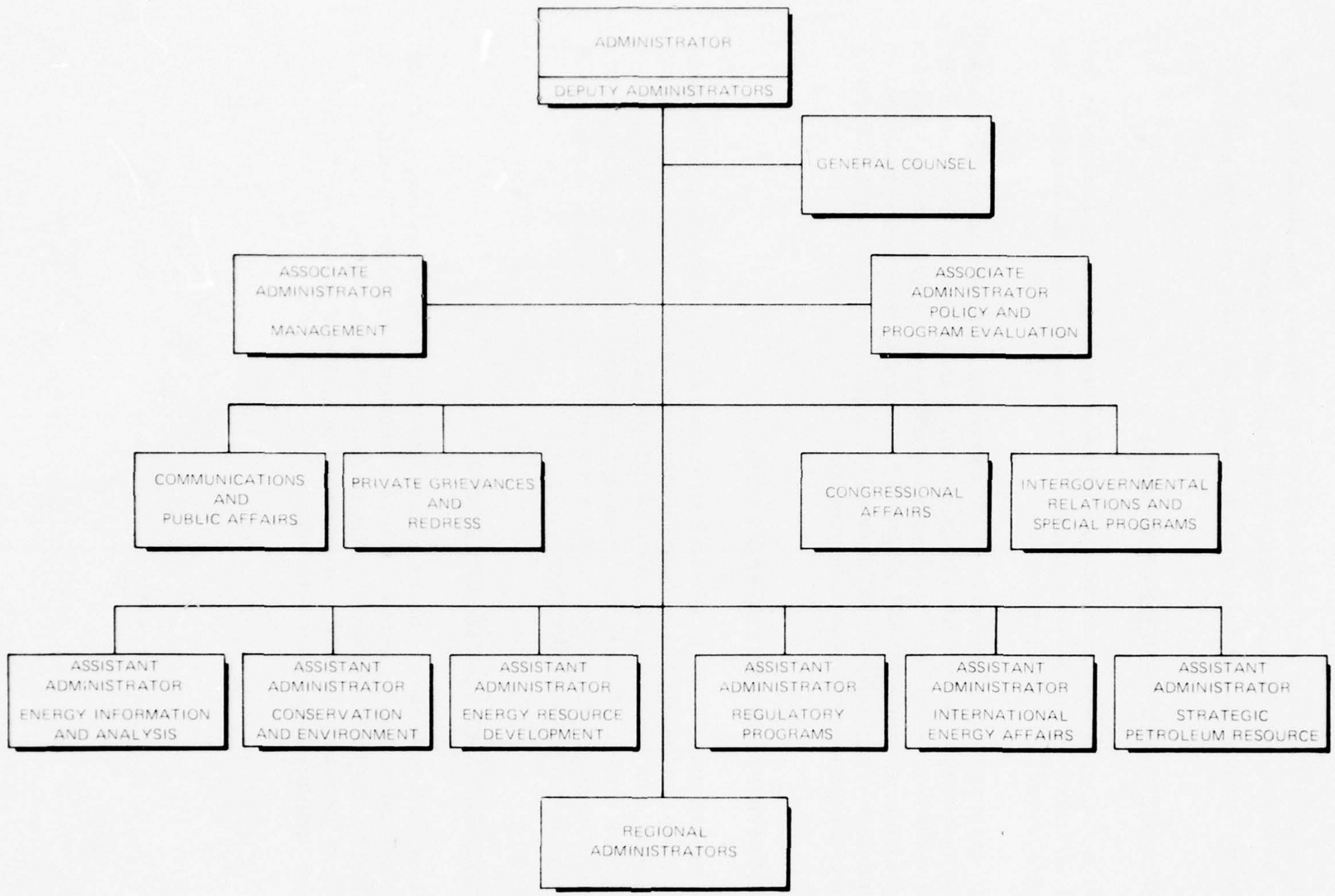


Figure C-4. ORGANIZATION OF FEDERAL ENERGY ADMINISTRATION

- Develop and oversee the implementation of voluntary and mandatory energy conservation programs that promote the efficient use of energy.
- Ensure that environmental concerns are balanced with national energy goals.

3.4 ENERGY RESOURCE DEVELOPMENT (ERD)

ERD is responsible for developing and implementing programs to increase production and utilization of energy from present domestic sources and for facilitating the development of new domestic energy sources.

ERD encourages the development of oil, natural gas, coal, oil shale, nuclear, solar, and geothermal energy through plans, programs, and projects centered around increasing domestic production. ERD is also responsible for developing energy sources and facilities and for preparing programs that will mitigate the adverse effects of energy regulations on the expansion of energy supply. ERD analyzes the impact of present and future energy alternatives, technologies, and resource requirements.

3.5 INTERNATIONAL ENERGY AFFAIRS (IEA)

IEA reviews and coordinates all of FEA's international activities, National Security Council matters, international agreements, multinational energy negotiations, transportation of energy from abroad, and liaison with defense and nuclear energy agencies. IEA develops policy options for oil sharing, mandatory conservation, emergency supply, and multinational energy programs. The development and evaluation of U.S. import/export foreign policy is also IEA's responsibility.

3.6 STRATEGIC PETROLEUM RESERVE (SPR)

To lessen U.S. vulnerability to the adverse effects of severe energy supply interruptions, the SPR office is tasked with the storage of substantial quantities of petroleum. To accomplish this goal, it must acquire storage facilities; determine where, how much, and what kind of petroleum to store; and establish policies and procedures for the distribution and transportation of the petroleum.

4.0 FEDERAL POWER COMMISSION (FPC)

FPC's authority to monitor and regulate wholesale electric rates, issue natural gas certificates and rates, perform water resource appraisal studies, conduct environmental impact studies, develop electric power and natural gas, and regulate natural gas pipelines was assumed by DOE on 1 October 1977. DOE's Federal Energy Regulatory Commission is responsible for carrying out these functions.

Before establishment of DOE, FPC's budget request for FY 1978 totaled $42,785,000. The FY 1978 budget for the seven program areas transferred from FPC to DOE is:

Program	Budget
Water Resources Analysis	$ 1,755,000
Hydroelectric Licensing	4,404,000
Electric Utility Regulation	2,155,000
Gas Certificates Regulation	5,346,000
Gas Rate Regulation	4,848,000
Industry Systems Analysis	13,283,000
Compliance and Legal Support	11,034,000
Total	$42,785,000

5.0 DEPARTMENT OF INTERIOR (DOI)

Established over 126 years ago, DOI has been actively involved in the management of federal lands and resources directly related to energy. (See Figure C-5.) Many of DOI's energy-related programs have been transferred to DOE, including:

- Authority with respect to the four power administrations.
- Power marketing functions of the Bureau of Reclamation.
- Responsibility for Falcon and Amistad Dams.
- Promulgation of regulations to achieve the most equitable and efficient development of federal leases as established under the Outer Continental Shelf (OCS) Lands Act, Mineral Lands Leasing Act for Acquired Lands, Geothermal Steam Act of 1970, and the Energy Policy and Conservation Act.
- Establishment of production rates for all federal leases.
- Bureau of Mines authority over data gathering, coal preparation and analysis, and R&D relating to energy mineral extraction technologies.

The DOE Organization Act contains provisions for the Secretary of Energy to consult the Secretary of Interior during the preparation of federal lease regulations. The act also gives the Secretary of Energy the authority to disapprove any condition or term of a federal lease that relates to the Secretary of Energy's area of responsibility before it is granted by DOI.

DOI retains full authority for the preparation of environmental impact statements with respect to federal leases. In the transfer of certain federal leasing functions to DOE, DOI also retains authority over Indian lands and resources.

DOI offices and bureaus that contribute to energy programs are described below. The effect of the establishment of DOE on these offices and bureaus is also discussed.

5.1 ASSISTANT SECRETARY FOR ENERGY AND MINERALS

Before the establishment of DOE, the responsibilities of the Assistant Secretary for Energy and Minerals were carried out by several offices and bureaus, including the U.S. Geological Survey (USGS), Bureau of Mines (BuM), Mining Enforcement and Safety Administration, and the Regional Power Administrations. The Assistant Secretary for Energy and Minerals has been responsible for key energy policies and frequently has represented DOI's energy position for interagency efforts and before Congress. It has not been determined what effect the establishment of DOE will have on this position. It is

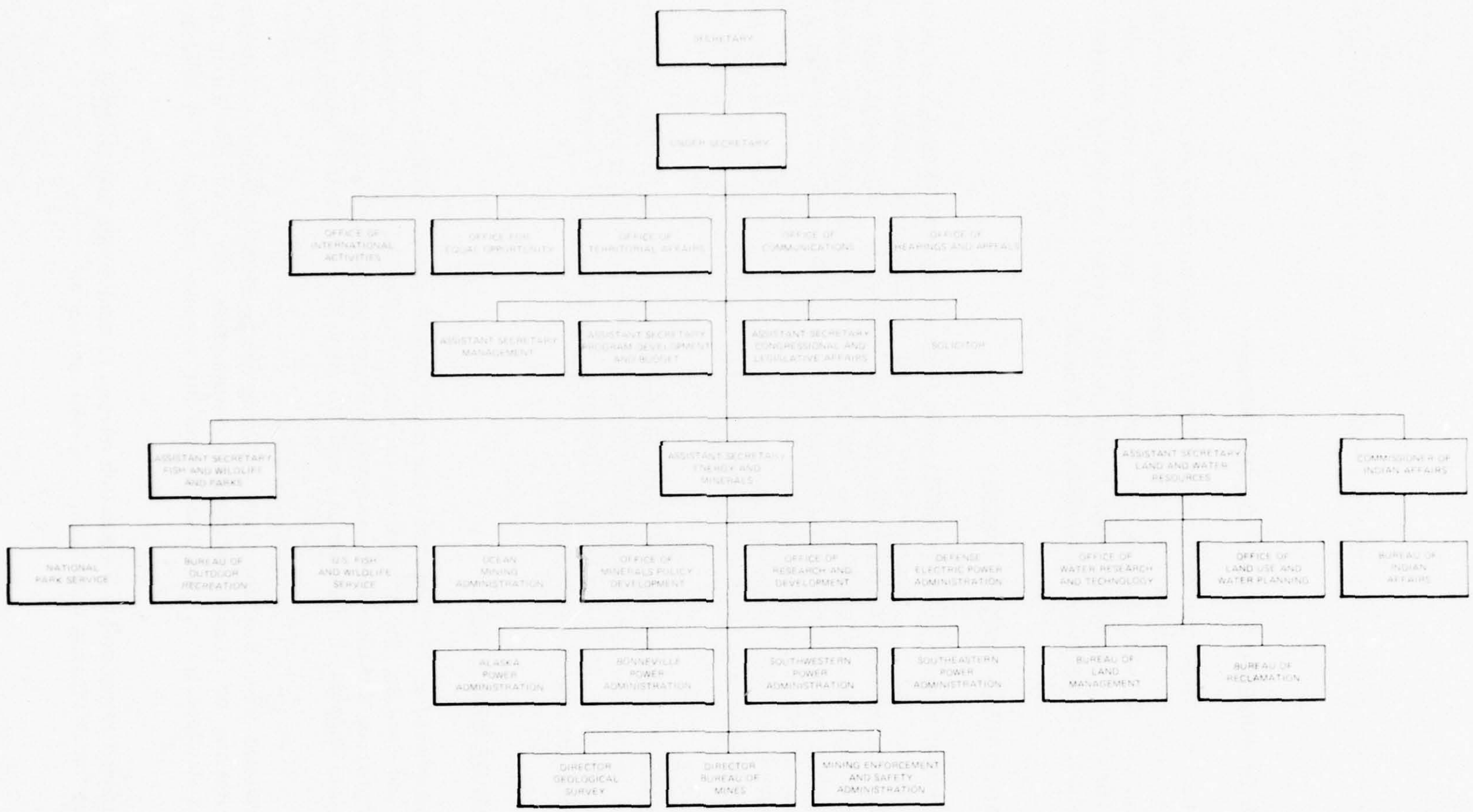


Figure C-5. ORGANIZATION OF DEPARTMENT OF INTERIOR

certain that if the position is maintained within DOI, the responsibilities will change significantly.

5.2 OFFICE OF MINERALS POLICY DEVELOPMENT

This office was established on 17 April 1974 to oversee the development of policies, programs, and legislative initiatives. It has also been responsible for minerals conservation programs, analyses of policy options, and coordination of policy and mineral analyses within the department. The office, which remains in DOI, serves the assistant secretary to forecast, evaluate, and appraise mineral plans and programs.

5.3 U.S. GEOLOGICAL SURVEY (USGS)

Since its establishment in 1879, USGS's basic function has been to classify all public lands and examine the geological structure, mineral resources, and mineral products. USGS has been responsible for conducting geological surveys, including geophysical and geochemical studies to develop data and knowledge for use in evaluating the nation's mineral resources; regulating the mining operations of private industry; and regulating oil and gas leases on public lands, i.e., Indian lands, the OCS, and certain naval petroleum reserves. USGS's regulating functions are to ensure maximum utilization and prevent waste of mineral resources, limit environmental damage, and protect public health and safety.

DOE assumed responsibility, to some extent, for USGS energy data gathering functions for inclusion in the Energy Information Administration, which will serve as the U.S. energy data bank. DOE also assumed authority to regulate federal leasing of public lands (except in the case of Indian lands).

5.4 BUREAU OF MINES (BuM)

BuM, established in 1910, has been the major federal agency for improving mineral technology and assuring the effective use of energy resources. BuM has encouraged private enterprise in the use of new technologies while maintaining informaton files to ensure adequate supplies of minerals and fuels to meet the present and future requirements.

DOE assumed some BuM functions, including energy-related economic information and data gathering on mineral production, consumption, etc.; coal preparation and analysis; and development of new technologies for increased production of solid fuel minerals.

BuM retained responsibility for research relating to mine health and safety as well as the environmental and leasing consequences of solid fuel mining.

5.5 MINING ENFORCEMENT AND SAFETY ADMINISTRATION

The Mining Enforcement and Safety Administration conducts programs to control health hazards and reduce injuries in mineral extraction operations, formulates standards for health and safety, and carries out inspections and investigations. This administration, which remains in DOI, enforces the Federal Metal and Nonmetallic Mine Safety Act and portions of the Federal Coal Mine Health and Safety Act of 1969.

5.6 REGIONAL POWER ADMINISTRATION

The basic functions of the four major DOI regional power administrations are to market and distribute electric power and energy from federal hydroelectric projects. These projects are constructed and operated by either the Army Corps of Engineers or the Bureau of Land Reclamation. The Bonneville Power Administration, Alaska Power Administration, Southeastern Power Administration, and Southwestern Power Administration were transferred to DOE as separate organizational entities, each to have an administrator appointed by the Secretary of Energy.

5.7 OTHER ENERGY-RELATED DOI AREAS

5.7.1 Bureau of Land Management (BLM)

BLM was established in 1946 to assume the responsibility for the conservation, management, and development of 450 million acres of land containing natural resources. Its primary energy-related function, under its Energy and Minerals Management Program, has been to administer mining and mineral leasing on 310 million acres of mineral estate and about 1.1 billion acres of the OCS. DOE will set the leasing policy for the timely development of energy resources, while BLM maintains responsibility for land and resource values, environmental impact caused by development, and other specific provisions relating to the individual leases.

5.7.2 Bureau of Reclamation

The Bureau of Reclamation has been responsible for implementing the Reclamation Act of 1902, which authorizes the Secretary of Interior to locate, construct, operate, and maintain work for the storage, diversion, and development of waters for the reclamation of arid and semiarid lands in the western United States. This program has significant impact on the development of energy resources in western areas because of its power to plan for the regulation, conservation, and use of water and related resources.

The Bureau of Reclamation also markets hydroelectricity, operating more than 50 power plants. This function, including the construction, operation, and maintenance of transmission lines and attendant facilities, was transferred to DOE.

5.7.3 Office of Water Research and Technology (OWRT)

The objective of OWRT, which remains in DOI, is to acquire the understanding and knowledge needed to solve or mitigate high-priority water resources problems and to continue the development of desalination processes. OWRT research activities include finding solutions to energy-related problems involving water, such as:

- Assessing the impact of coal mining and oil shale development on local and regional water resources.
- Developing ship-spoil reclamation for reuse and water quality protection.
- Developing a methodology to minimize any adverse water-related consequences resulting from fossil fuel development in the western United States and Appalachia.
- Modeling water supply allocation.
- Developing acid mine drainage control.
- Studying the conservation of cooling and process water.
- Developing water recycling and water reuse means.
- Studying water conservation.

5.7.4 U.S. Fish and Wildlife Service

As part of the Fish and Wildlife Service's responsibilities to protect living natural resources, it contributes to the management of the land and water environments that sustain wildlife. These efforts include:

- Biological monitoring—surveillance of pesticides, heavy metals, and thermal pollution.
- Ecological studies.
- Environmental impact assessment—river basin studies, including hydroelectric dams, nuclear power sites, and environmental impact statement review.
- Area planning and preservation—including river basins, wilderness areas, and special studies (such as oil shale and geothermal energy).

The service remains in DOI.

6.0 DEPARTMENT OF COMMERCE (DOC)

DOC established an Office of Energy Programs (OEP) in 1973 to assist in saving the business community money and to help to promote an energy conservation ethic within business. The voluntary industrial conservation program initiated by OEP as part of its program was transferred to DOE on 1 October 1977. OEP's other plans and programs, as described in the following summary, are continuing in DOC.

Four approaches have been adopted by OEP to attain its objectives of energy economy and conservation in business. The first is to encourage business firms to conserve energy in the operation of their own buildings and manufacturing processes; second is to urge the business community to manufacture and market more energy-efficient products. Third, businesses are asked to encourage energy conservation by their employees, customers, and communities. Finally, the office is participating directly in energy conservation through an internal program aimed at reducing consumption.

While the OEP plays an important role in DOC program planning, the National Bureau of Standards (NBS) presents a more technical approach to energy conservation. Within NBS, OEP oversees and coordinates energy conservation for buildings, appliances, and community services (utilities).

The development of computer techniques for estimating energy requirements, the establishment of performance criteria to evaluate systems provided for by the Solar Heating and Cooling Demonstration Act, and studies relating to MHD and LNG are all important programs now being pursued by NBS.

Other divisions within DOC also have energy program responsibilities. The Maritime Administration, through its association with industry representatives, encourages the reduction of petroleum consumption through the elimination of waste, conservation of energy, and utilization of energy-efficient procedures.

The U.S. Merchant Marine Academy has started a project to develop an improved combustion technique to increase marine boiler efficiency by at least 6 percent. One of its more unique programs is a joint effort with the Office of Science and Technology, Office of Telecommunications, and FEA to develop a telecommunication plan to cut down business travel. The plan is being tested using a decentralized federal agency.

The planning of deep-water ports, coastal zone refineries, and nuclear power plants are all subject to the management of the National Oceanic and Atmospheric Administration (NOAA). NOAA is responsible for coastal zone management and planning involving OCS oil and gas development, including environment assessment and on-shore impacts.

7.0 DEPARTMENT OF DEFENSE (DOD)

The most significant effect of the recent federal energy reorganization on DOD is the transfer of the Navy's responsibility for petroleum and oil shale reserves to DOE. Other energy-related programs to reduce DOD's dependency on the use of petroleum-based fuels are continuing within DOD.

Energy has become an increasingly important consideration in the development and acquisition of any new major weapon system. Accordingly, DOD, the largest U.S. energy user, has considered energy fuels characterization, engine efficiency, and fuel economy in mobility and weapon systems design important parts of its research, development, test, and evaluation (RDT&E) program. Since the oil embargo of 1973, DOD has directed that there be additional R&D effort to identify energy alternatives that are suitable supplements or replacements for its current, petroleum-based supply of energy.

The DOD energy planning and research and development organizational structure (described in Chapter 6) includes a Defense Energy Policy Council, chaired by the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), which develops broad energy policy guidelines, and a Directorate for Energy, supported by a Defense Energy Action Group, to coordinate actions within DOD.

For convenience, the draft Defense Energy Initiatives Plan (November 1976) divides DOD energy matters into three parts:

- Energy Conservation.
- Petroleum/Energy Logistics.
- Energy Research and Development.

7.1 DOD ENERGY CONSERVATION

Within DOD, energy conservation is directed toward minimizing energy consumption by its more efficient usage, without reducing the necessary level of military readiness or its associated training.

An Energy Conservation Investment Program (ECIP) was established by DOD in FY 1976 to reduce energy consumption through self amortizing retrofit projects to existing facilities. Projects within the ECIP include energy control and monitoring systems; heating and air conditioning modifications; insulation and glazing; lighting conversions; and boiler modifications, steam system modifications, and miscellaneous building alterations to improve energy efficiency.

A Defense Energy Information System (DEIS) was established to facilitate energy management and energy conservation by providing data from each service and DOD user agency on the availability, consumption, and resupply of petroleum products and other forms of energy that provide power and/or heat to military installations, ships, and aircraft.

Flight simulators (synthetic flight training devices) are being increasingly used by the Services both to increase the effectiveness of training as well as to conserve energy. Simulators are also being used to a lesser degree for other mobile equipment training for both land and sea.

In FY 1974, the Defense Contract Audit Agency initiated a program to assess the energy utilization programs at more than 200 major defense contractor locations. The audit reports indicated that most major contractors responded favorably to the need for imp.oved energy conservation.

Coal has been designated as the preferred fuel for fossil-fueled heating plants where feasible. New boilers and heating plants requiring natural gas will not be planned, and provision for oil or solid fuel backup for natural gas plants is being implemented where possible.

DOD is cooperating with ERDA and FEA in conducting energy conservation demonstration projects, such as the joint Navy/ERDA fluidized-bed boiler project at Great Lakes.

7.2 DOD PETROLEUM/ENERGY LOGISTICS

DOD established an Integrated Material Management (IMM) program for bulk petroleum in 1972. The establishment of the IMM generated a need within the Defense Supply Agency for a fully automated system operating on a worldwide basis for the management of the wholesale procurement and supply of petroleum fuels. A Defense Fuel Automated Management Systems (DFAMS) is also being established to improve inventory and financial controls, increase product use visibility, and improve methods of demand forecasting.

DOD is providing assistance to FEA in establishing an SPR and is working to strengthen the SPR concept and increase the ultimate quantity of fuel being stored in an effort to better provide for civil and military requirements in a wartime emergency situation.

DOD is also evaluating NATO proposals for standardization of naval and aviation fuels. FEA has been requested to survey industry to determine the import in industry capability and supply of other products if the Air Force converts to JP-8 from JP-4 aircraft fuel. The Navy is well along in converting all ships using naval ships fuel oil to naval diesel.

7.3 ENERGY RESEARCH AND DEVELOPMENT

The multitude of energy-relevant R&D activities being undertaken by DOD can be categorized as being energy-motivated (those that are in direct response to the national energy R&D program) or energy-related (those that have been initiated as part of DOD's primary mission but also have a secondary benefit in either increasing energy supply or reducing consumption). These activities include:

ARMY

- Energy-motivated
  - Multifuel capability for ground operations.
  - Advanced fuels and power systems.
- Energy-related
  - Improved vehicle energy conversion and transmission.
  - Mobile electric power systems.

NAVY

- Energy-motivated
  - Multifuel capability for ship operations.
  - Use of less critical fuels, syncrude, and alternative fuels.
  - Reduction in nonpropulsive energy consumption.
  - Improved conversion efficiency.
- Energy-related
  - More efficient ship propulsion.

AIR FORCE

- Energy-motivated
  - Multifuel capability for aircraft.
  - Alternate fuels for aircraft.
- Energy-related
  - More efficient aircraft propulsion.
  - Improved aerodynamic drag reduction.

ALL SERVICES

- Energy-motivated
  - Optimum utilization of technology and equipment for installations and buildings.
  - Advanced technology for installations and buildings.

Basic to the identification and evaluation of specific DOD energy R&D initiatives is a comprehensive evaluation of future energy R&D requirements. In this regard, the Navy has undertaken a major effort to establish a Navy energy plan that includes its perception of the energy R&D program that it should be conducting. This plan contains many of the elements that will be required to establish the energy R&D requirements for DOD. The

Air Force is currently conducting an energy management study that may also be useful in preparing a comprehensive DOD-wide evaluation of future energy R&D requirements. Additionally, the Army has instituted a study effort that focuses on a revised management organization/structure across the energy spectrum.

8.0 DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)

HUD's responsibilities for developing and promulgating energy conservation standards for new buildings and for implementing a national energy conservation demonstration program were transferred to DOE. HUD retained several energy-related programs involving utilization of solar heating and cooling. One such activity is the first large-scale test of solar energy in housing, which is being sponsored by HUD under the Solar Heating and Cooling Demonstration Act. This joint DOE-HUD-DOD program will investigate the practical widespread application of solar energy for home heating and cooling. It was announced in January 1976 that $1 million in grants for the installation of solar units in 143 new and existing dwelling units in 27 states will be made available by HUD.

9.0 DEPARTMENT OF STATE (DOS)

The global scope of the energy issue has made DOS an important party in development of international energy policy and negotiations relating to oil and other energy sources. The DOE Organization Act directs that the Secretary of Energy coordinate energy issues of international concern with the Secretaries of State, Treasury, and Defense. The Act provides that the Secretary of State shall continue to exercise primary authority for the conduct of foreign policy relating to energy and nuclear nonproliferation.

Within DOS, the Office of Fuels and Energy provides staffing for the energy-related programs and serves as the coordinator for activities with the Department of Treasury, DOC, DOE, and the Office of Management and Budget.

Another major function of the Office of Fuels and Energy is its responsibility for U.S. participation in the International Energy Agency (IEA). Since its organization in November 1974, IEA has been working to establish oil-sharing agreements to meet present needs and to encourage cooperation among the members to aid conservation efforts to reduce dependence on imported energy.

The Office of Nuclear Energy and Energy Technology Affairs at DOS provides assistance for long-term energy development cooperation among nations, primarily nuclear energy safeguards and security. This office also provides input for U.S. participation in IEA activities. The office works closely with other federal agencies to monitor international energy R&D activities.

10.0 DEPARTMENT OF TRANSPORTATION (DOT)

DOT, under the Motor Vehicle Information and Cost Savings Act, is responsible for establishing fuel economy standards. Provisions of the DOE Organization Act require that the Secretary of Transportation consult the Secretary of Energy in carrying out the responsibilities associated with the fuel economy standards.

The Coast Guard, which is within the jurisdiction of DOT during peacetime, has an office of research and development which is charged with the administration of programs to meet the Coast Guard's needs for new or improved systems, equipment, methods, and procedures. These efforts include research and development of energy technologies.

The basic strategy for the Coast Guard's energy R&D program has two objectives:

- Conservation through the application of alternate strategies and alternate engineering.
- Substitution of presently used conventional energy sources by a more practical application of a conventional source and by nonconventional such as solar, wind, and wave energy.

Current R&D includes conservation projects for the cutter fleet, a solar heating and cooling demonstration program for shore facilities, and a program to develop solar-, wind-, and wave-operated power packages for aids to navigation.

11.0 ENVIRONMENTAL PROTECTION AGENCY (EPA)

The energy-related role of EPA is to protect the public health and welfare from adverse environmental effects of programs designed to meet the nation's energy needs. Because of the potentially hazardous health and ecological effects associated with traditional, as well as new, technologies for fuel processing, conversion, and utilization, EPA has programs underway to develop the medical and technical data base to assess these problems. R&D efforts toward this end are mandated by the Clean Air Act, the Federal Water Pollution Control Act, and the Resources Recovery Act. Table C-3 shows the EPA energy-related budget for FY 1978. The large increase in health and ecological effects reflects EPA's changing program emphasis.

EPA's part in the energy program is organized into four areas:

- Conversion Utilization, and Technology Assessment, which emphasizes the

identification, characterization, assessment, and development of technology to control pollutants associated with utility and industrial combustion sources.

- Energy Extraction and Processing Technology, with objectives to increase rapidly the extraction and processing of domestic energy resources and to allow these energy sources to be used effectively in an environmentally compatible manner.
- Energy Health and Ecological Effects, designed to identify all adverse environmental effects, which would lead to regulatory and control technology requirements associated with energy extraction, conversion, and use.
- Technical Support, including developing cooperative regionally oriented R&D projects and baseline conditions monitoring the development of scientific data for regulatory functions are part of the support.

Problems of immediate concern to EPA are:

- The conversion of oil- and gas-fired boilers to coal burning boilers that will burn high-sulfur coal, resulting in additional emission of particulates, sulfur compounds, and other combustion residues to the environment.
- The increased use of coal and oil shale, which will accelerate area mining for coal and oil shale in semiarid western areas, raising serious questions about the restoration of mined lands and the impact on ground and surface water resources.

These and other problems have short-, intermediate-, and long-term implications. EPA's approach is to initially apply its regulatory requirements to reduce the short-term impact, then follow with research directed toward problem identification and assessment in the intermediate term, and address the long-term problem through the strategy of prevention.

Table C-3. EPA ENERGY-RELATED FUNDING, FY 1978
(Thousands of dollars)

Appropriation	Actual 1976	Budget Estimate 1977	Current Estimate 1977	Estimate 1978	1977-78 Change
Extraction and processing technology	20,890	24,227	25,400	24,350	-1,050
Conservation, utilization and technology assessment	27,075	36,000	32,700	30,550	-2,150
Health and ecological effects	34,179	33,700	35,200	39,200	4,000
Technical support	892	2,500	3,062	2,237	-735
Total	83,036	96,427	96,362	96,427	65

12.0 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NASA energy research and technology efforts have been primarily to identify aeronautics and space program technology that can be applied to solving energy problems. Another aspect of NASA's energy program is cooperative effort with other agencies to speed the development of such technologies as wind power. NASA's Office of Energy Programs is responsible for both the dissemination of information and the coordination of programs relating to energy technologies. NASA has requested no direct funding for energy R&D in FY 1978. Its energy expertise will be available to ERDA and any agency on a reimbursable basis.

Negotiations have been underway between NASA and ERDA for funds to support the initial study and definition efforts to determine the technical and economic practicability of the Satellite Solar Electric Power Generation System. NASA reimbursable agreements with ERDA have included support of residential and commercial solar heating and cooling, wind energy, solar photovoltaics, and geothermal energy programs.

13.0 NATIONAL SCIENCE FOUNDATION (NSF)

NSF was established as the nation's center to promote and strengthen basic scientific research and manpower, particularly through science and education programs. NSF has emphasized programs that have the potential to strengthen and significantly contribute to science and society. For FY 1978, NSF's budget request was $885 million, an increase of $87 million, 11 percent, over FY 1977.

Studies relating directly to energy are covered by the Research Applied to National Needs (RANN) program. The RANN program has requested a budget for FY 1978 of $78 million to support problem-focused research in five major areas: resources, $11.5 million; environment, $34.5 million; productivity, $23 million; intergovernmental science and R&D incentives, $7 million; and exploratory research and technology assessment, $2 million. In FY 1978, the RANN program will support research on renewable resources, in particular biomass conversion, management of resource systems and nonrenewable resources.

Since research and development for energy resources and energy environmental effects is being done by agencies established for that specific purpose, the RANN program is emphasizing other programs of national concern related to the environment, technology and economic productivity.

14.0 OTHER ENERGY-CONCERNED AGENCIES

14.1 COUNCIL ON ENVIRONMENTAL QUALITY (CEQ)

CEQ was established by the National Environmental Quality Act of 1969. It consists of three members appointed by the President, responsible for formulating and recommending national policies to improve the quality of the environment.

CEQ includes an Energy Program Staff, which has been assigned to assess various aspects of energy questions as they impact upon environmental considerations. CEQ has arranged with various federal agencies, including NSF, and academic organizations to carry out a number of specific studies:

- Environmental impact assessment of oil and gas operations on the Atlantic and Alaska OCS.
- Study of offshore nuclear power plants and resulting environmental hazards.
- Study of siting and safety of liquid natural gas facilities.
- A general report on the environmental impact of end uses of various types of energy.
- Effects of interfuel competition on environmental concerns.
- Environmental impacts of developing deepwater ports.

14.2 ENERGY RESOURCES COUNCIL

The Energy Resources Council was established by the Energy Organization Act of 1974. It is an interim interagency coordinating organization composed of:

Secretary of Interior, Chairman
Administrator of FEA
Administrator of ERDA
Secretary of State
Director of Office of Management and Budget
Assistant to the President for Economic Affairs
Secretary of the Treasury
Secretary of Defense
Attorney General
Secretary of Commerce
Secretary of Transportation
Chairman of NRC
Administrator of EPA
Chairman of CEQ

Director of NSF
Executive Director of the Domestic Council
Administrator of General Services Administration
Special Assistant to the President for Consumer Affairs.

The council will terminate when a permanent department responsible for energy and natural resources is established or two years after the council becomes effective, whichever occurs first.

14.3 OFFICE OF TECHNOLOGY ASSESSMENT (OTA)

OTA is responsible for providing Congress with early indications of the probable beneficial and adverse impacts of technology applications, including identification and analysis of alternative implementation methods. OTA also identifies areas in which additional research or data collection is required to assess a technology program, and maintains coordination with the Congressional Research Service, the General Accounting Office, and NSF in order to coordinate research efforts.

14.4 NUCLEAR REGULATORY COMMISSION (NRC)

NRC was established by the Energy Reorganization Act of 1974. The regulatory and licensing authority of the former Atomic Energy Commission were transferred to the NRC, including the functions of the Atomic Safety and Licensing Board Panel, the Atomic Safety and Licensing Appeal Panel, and the Advisory Committee on Reactor Safeguards. NRC is the federal agency responsible for nuclear regulatory research, safeguards, and enforcement.

14.5 TENNESSEE VALLEY AUTHORITY (TVA)

TVA programs include such energy-related activities as:

- Regional water resources development, including river and flood control projects, water quality management, development of navigation, and concurrent environmental planning, which includes recreation, fisheries, and waterfowl resources development (funding of $48.6 million for FY 1978).
- General resource development, including R&D in forestry, fish and game, watershed protection, and land reclamation after surface mining (funding of $16.8 million for FY 1978).
- Power development programs to supply an area of 80,000 square miles, including planning, contruction, and maintenance of nuclear power plants and a pumped storage hydroelectric project.

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Note: A letter (f) following a page number indicates a figure and a (t) indicates a table.

APPENDIX B

APPENDIX C